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Implementation of Hybrid Methods in the Application of Experimental Psychology for Analysis of Mental Endurance Conditions

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Abstract-Psychology is the study of behavior and mental processes of a person. In psychology, psychological tests or psychological tests are often used as part of the selection to determine the maximum performance of prospective employees based on mental endurance conditions from the factors of speed, accuracy, and consistency. One of the psychological test tools is the Mirror Tracer Apparatus which is used to determine the condition of a person's mental endurance with visual coordination in responding to the inverted image of an object seen through a mirror. Because the use of the Mirror Tracer Apparatus only uses one pattern, and the cost is quite expensive, an Experimental Psychology Implementation Application is created which is implemented in an Android-based application to make it easier with many patterns. This application is designed using a combination of two methods (Hybrid Method). The Fuzzy Mamdani method is used to generate a mental health condition level score, and the Template Matching method is to match the pattern of the resulting images with the template. These two methods aim to apply the psychological knowledge base to the application. Data processing is carried out by giving weight ratings to the experimental tools carried out by the user. The results of this study have been tested on psychologists, resulting in a score of 83% agreeing that the application can be used as an alternative test tool, and 92% of prospective new employees stated that the application can determine the condition of mental endurance.

Keywords: fuzzy mamdani, hybrid methods, mirror tracer, experimental psychology, template matching

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1. Introduction

One of the benefits of using psychological tests is that they are used as a tool to determine human abilities and traits. Especially in industrial psychology, besides job placement selection, and adjustment of workers who are already working, and also to determine the conditions of work (performance reqruitments), it is necessary to carry out psychological tests that are useful for the purposes of prognosis diagnosis and therapy for private disorders [1]. According to Erik Saut H, humans are in a state of depression makes the condition of the human soul even more shaken, if the human soul is shaken it will be affected by the humans themselves. If our souls find coolness, calmness and happiness, it will also have an impact on our health, psychology and passion for life. If the soul is prosperous, we will be healthy and happy. If our souls are uncomfortable then we become depressed and suffering humans.

To conduct a psychological test, it is necessary to carry out Experimental Psychology research in which this research manipulates one of the variables to study the existence of a causal relationship [2] [3]. Psychology Experiments are carried out to determine the effects of the deliberate treatment by the researcher, then the researcher predicts the consequences of a manipulation of the research variables. Experimental psychology research was conducted with a comparison of manipulated and non-manipulated treatments. The purpose of psychological research Experiments to

determine interests, abilities, and resources (manpower, funds, and time). Qualitative variables in psychological tests in companies at level testing are determined in the selection of prospective employees to determine the character and performance of prospective employees, namely conditions of mental endurance based on accuracy, and consistency [4]. In the section which position is low, the test is conducted in an easy level, while the job position is middle, the testing used is a medium level. Then, the job position with a high position is tested with a hard level. One of the tools used for experimental psychology that can be used to determine mental endurance conditions is the Mirror Tracer Apparatus. Mirror Tracer Apparatus is an experimental psychology tool used to measure motor learning, the process of which involves the human response mechanism itself [5] [6].

In this study, the Mirror Tracer tool is implemented into an android application. Data processing is carried out using a combination of two methods or a hybrid method. The method used is fuzzy mamdani and template matching. The use of these two methods is expected to represent the knowledge base of a psychologist's expert on the analysis of the mirror tracer experimental psychological test tool. The application of the Fuzzy method is used to determine the condition of mental endurance based on the score results in the Mirror Tracer application simulation. The scores obtained are processed using the Fuzzy Mamdani method, with its simple structure using the MIN-MAX or MAX-PRODUCT operation [7]. The variables required for this operation are the length of time to draw the pattern, as well as the number of error points. Then, to calculate the accuracy level of the pattern match of the resulting pattern file with the pattern template using the Template Matching method. It is expected that the implementation of experimental psychology to determine conditions of mental endurance using the Fuzzy Mamdani method in industrial psychology can determine the placement of workers in accordance with the conditions of mental endurance [8].

2. Methods

Cross-Industry Standard Process for Data Mining (CRISP-DM) is a standard that has been developed in 1996 which is shown to carry out process analysis of an industry as a problem-solving strategy of a business or research unit [9]. There are 6 phases in this CRISP-DM which are described in Figure 1. The process of developing this application adopts the CRISP-DM flow.

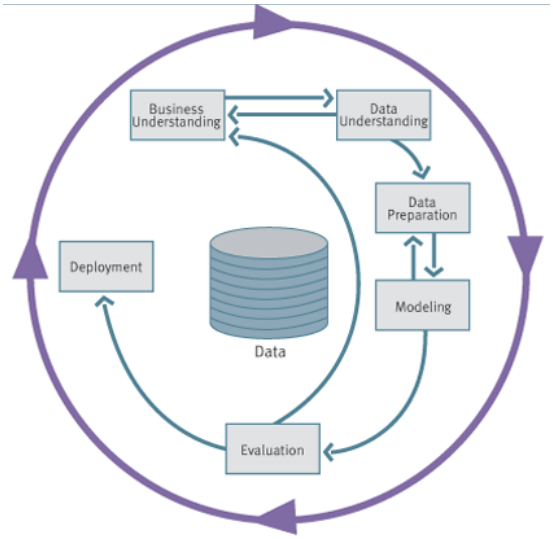

Figure 1. CRISP-DM phase

a. Business Understanding Phase

In experimental psychology using a mirror tracer tool, which tests using pattern images and requires a small cost, an application is made so that it can be efficient in replacing many pattern images, and it does not cost a lot. The purpose of this application is to implement the experimental psychology application in determining the condition of mental endurance with the factors of speed, accuracy, and consistency, using the Fuzzy Mamdani method based on the variable length of time to work and the number of error points, then matching the results of the input pattern image with the template pattern image using the Template method. Matching.

The limitations in implementing experimental psychology applications to determine conditions of mental endurance include the following:

1) The entity used in this application comes from experimental activities carried out by the subject.
2) This application implements the Experimental Psychology of the Mirror Tracer Tool.
3) The pattern template used to match the pattern file results comes from the psychologist's knowledge base

b. Data Understanding Phase

At this stage, the data collection is carried out first, all the necessary data will be processed thoroughly. Collecting pattern images data in the form of flat shapes, carried out by interviews with experts. Then, for the distraction process in testing the mirror tracer tool uses noise music data and quiet music. Quiet music is used to give a calm effect on the concentration of an object, and noise music is used to influence the heart rate on the object's concentration. The effect of quiet music and noise music are determined with different decibel levels

c. Data Processing Phase (Data Preparation Phase)

In this phase, data processing was carried out which was later be used in the modeling stage, so that later modeling can provide maximum results according to the desired target. The data that is processed is a pattern image in the form of a flat shape which is divided into 3 levels, namely the easy, medium, and hard level. The pattern division is divided based on the number of angles in the pattern image, a higher number of angles is associated to a harder level. Also, the distraction process by giving the effect of calm music and noise music is determined in decibels as in Table 1.

Table 1. Distraction Decibel Rate

No.	Kinds of Music	Decibel Level	Effects on Users
1	Musical instruments	30 dB	Make mind and mental calmer
2	Noise	80 dB	Affects the mind and has difficulty concentrating
3	Explosive Sound	120 dB	Affects heart rate

d. Modeling Phase

In this study, applying the modeling stage by making a test model using an Android-based tablet on the mirror tracer tool to prospective new employees. The test results in the results of the mental resistance level score using Fuzzy Mamdani logic because the suitability of data acquisition with fuzzy output is not linear or constant, such as Sugeno inference [10]. Then, calculate the percentage of pattern matches on the server using the Template Matching method. The template matching method is a method for comparing the reference image (template) with the test image [11].

e. Evaluation Phase

The evaluation is analyzed based on the knowledge base of the psychologist. Also, in the application, to determine the score results of the level of mental endurance conditions based on the parameters of the length of time when the user draws the pattern on the application, and the number of error points, namely the number of line pixel points that come out of the pattern path. Then, the server uses the Template Matching method to match the results of the input image with the template image obtained from psychologist data.

f. Deployment Phase

The deployment of this application is carried out by testing the application to prospective new employees, then providing a questionnaire to find out if the test results can be deemed to meet the requirements of the user, the application can be applied.

g. Data

The data used in this study are pattern image data in Table 2 for the Mirror Tracing Apparatus.

Table 2. Pattern Trial Data

No.	Pattern Name	Pattern	Level	Number of Angles
1	*Square*		*Easy*	4
2	*Circle*		*Easy*	0
3	*Parallelogram*		*Easy*	4
4	*Triangle*		*Easy*	3
5	*Five Star*		*Medium*	10
6	*Six Star*		*Medium*	12
7	*Seven Star*		*Medium*	14
8	*Eight Star*		*Medium*	16
9	*Advanced Shaped 1*		*Hard*	27
10	*Advanced Shaped 2*		*Hard*	26
11	*Advanced Shaped 3*		*Hard*	25
12	*Advanced Shaped 4*		*Hard*	26

h. Data processing

In this study, the data processed is pattern data on the Mirror Tracer tool consists of 2 parts, such as the pattern trial data and the template pattern data used for the template matching process. The division of the level is determined based on the number of angles in the pattern image, the higher number of angles of the pattern is associated to a more difficult level. Patterns with many angles are considered difficult because the process of testing the mirror tracer tool by drawing a pattern through a mirror image is the opposite direction of the user's point

of view when drawing. Therefore, when passing the corner, it is necessary to involve the user's motor response, in order to observe the effect of treatment on the user's mental endurance. The level on the test is determined based on request, if applying for a very difficult job requires construction and a high level of mental endurance, then use a higher level, namely the hard level, and vice versa based on the level of work that is easier using the easy level and the medium level. In the testing process, the level selection is determined by the psychologist concerned.

Table 3. Template Pattern Data

No.	Pattern Name	Pattern	Level	Number of Angles
1	*Square*		*Easy*	4
2	*Circle*		*Easy*	0
3	*Parallelogram*		*Easy*	4
4	*Triangle*		*Easy*	3
5	*Five Star*		*Medium*	10
6	*Six Star*		*Medium*	12
7	*Seven Star*		*Medium*	14
8	*Eight Star*		*Medium*	16
9	*Advanced Shaped 1*		*Hard*	27
10	*Advanced Shaped 2*		*Hard*	26
11	*Advanced Shaped 3*		*Hard*	25
12	*Advanced Shaped 4*		*Hard*	26

i. Fuzzy Mamdani

In this research, fuzzy mamdani logic is used to earn the output in the form of determining the condition of mental endurance, for the parameters obtained from the results of interviews with psychology experts from the State University of Malang.

The Mamdani Method is also known as the Max-Min Method. To obtain the output, four stages are required:

1) *Fuzzy Set*

a) **Time Variable**: Time variable is the point of measuring the length of time to draw the pattern in units (seconds) Times are grouped into fuzzy sets, shown in Figure 2, 3, and 4:

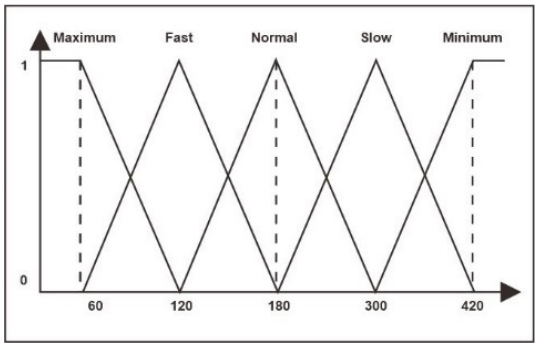

Figure 2. Graph of Easy Time Variable Membership Functions

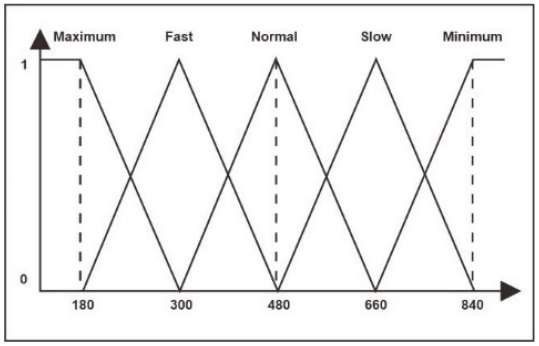

Figure 3. Graph of Medium Time Variable Membership Functions

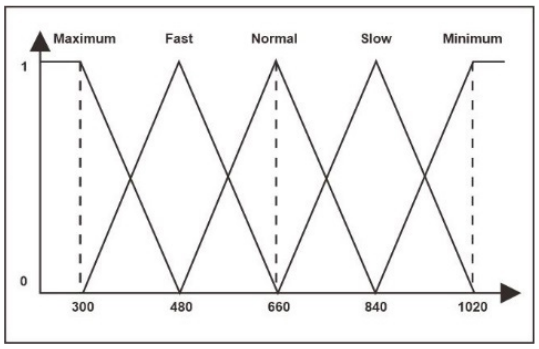

Figure 4. Graph of Hard Time Variable Membership Functions

b) **Variable Number of Error Points:** In this research, the number of error points is obtained from the number of angles of each pattern and is grouped with a fuzzy set, shown in Figure 5, 6, and 7:

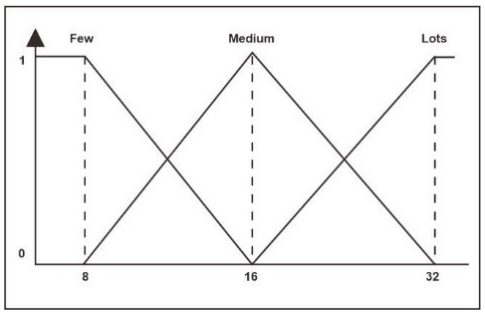

Figure 5. Graph of Membership Function variable the number of error points at the easy level

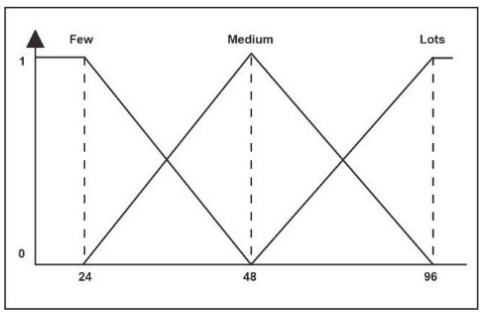

Figure 6. Graph of Membership Functions variable number of error points at medium level

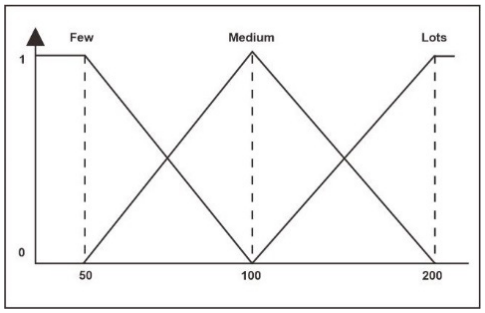

Figure 7. Graph of Membership Functions variable the number of error points on the hard level

c) **Variable Level of Mental Endurance Conditions**: In this study, to determine the results of the level of mental endurance conditions based on time and the number of error points grouped with fuzzy sets, shown in Figure 8:

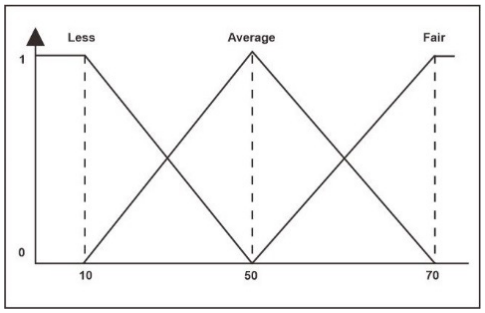

Figure 8. Graph of the membership function level of the state of endurance

2) *Implication Function*

According to Chen & Pham (2001), membership value as a result of operating two or more sets on the *Min* implication function is defined as follows:

$$\propto -\boldsymbol{predicate_i} = \boldsymbol{\mu_{A_1[x_1]\cap,\ldots,\cap A_n[x_n]}} \quad (1)$$

There are 15 rules of implication function in the Fuzzy Mamdani Method, described in Table 4:

Table 4. Rule Base System

IF	Time	AND Error	THEN Fuzzy Output
1	Maximum	Few	Fair
2	Fast	Few	Fair
3	Normal	Few	Fair
4	Slow	Few	Average
5	Minimum	Few	Less
6	Maximum	Medium	Fair
7	Fast	Medium	Average
8	Normal	Medium	Average
9	Slow	Medium	Less
10	Minimum	Medium	Less
11	Maximum	Lots	Average
12	Fast	Lots	Average
13	Normal	Lots	Less
14	Slow	Lots	Less
15	Minimum	Lots	Less

3) *Composition of Rules*

In the process, a combination of fuzzy rules occurs to explain the consequent results obtained from each fuzzy rule which is modified with the respective fuzzy set solution and combined with other consequent modification results. The equation for determining the composition of the rules is as follows:

$$\boldsymbol{\mu_{sf}[xi]} = \max\left(\boldsymbol{\mu_{sf}[xi]}, \boldsymbol{\mu_{kf}[xi]}\right) \quad (2)$$

note:

$\mu_{sf}[xi]$: fuzzy solution membership value up to for number *i*

$\mu_{kf}[xi]$: the membership value of the fuzzy consequences of rule up to for number *i*

4) *Defuzzification*

In this study, the defuzzification process uses the Centroid method by taking the center point value (x*) from the area in the membership function B. The centroid method formula is defined as:

$$\boldsymbol{x^*} = \frac{\int x \; x\,\mu_B(x)dx}{\int x \;\; \mu_B(x)dx} \quad (3)$$

for continuous domains, and

for discrete domains.

$$x^* = \frac{\sum_{i=1}^{n} x_i \mu_B(x_i)}{\sum_{i=1}^{n} \mu_B(x_i)} \quad (4)$$

j. Template Matching

The Manual Template Matching calculation will be described based on the processes in template matching [12], namely:

1) Canvas Input Process
   In the canvas input process, we make the input image from the user into a bitmap image, so that it can be read by the system. In this process, there is a change from the user's writing into an image or bitmap, so that it can be read by the system. After it is read into an image, the RGB reading process is carried out to distinguish between the three colors including red, green and blue.
2) Grayscale process
   In converting the color to grayscale, it is necessary to calculate the pixels in an image that has RGB color information, then add the color by switching each color with a different number so that the average value is obtained in RGB color. The average value that will be used to color the image pixels so that it becomes a grayscale color.

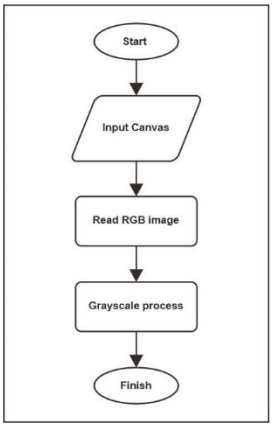

Figure 9. Canvas Input Process Flowchart

3) Binarization Process
   The conversion of a true color (24 bit) image to a binary image (1 bit) is carried out by means of a thresholding operation. The floating operation groups the grayscale value of each pixel into two classes, namely black and white. Black represents the object color while white represents the background color.
4) Template Process
   At the template process stage, there is a calculation between the image input and the image template, in which the calculation is to match the image input in order to obtain a value that matches the image template.

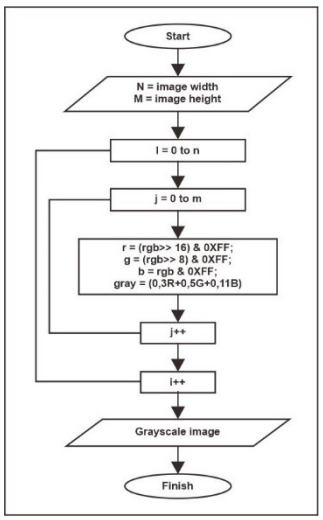

Figure 10. Grayscale process

The steps for calculating pixels in x, y coordinates in the Circle Pattern matrix A (input pattern) with matrix B (template pattern) as shown in Figure 10. The calculations between matrix A (input pattern) and matrix B (template pattern) is shown as follows:

$$(0-0)^2 + (1-1)^2 + (1-1)^2 + (0-0)^2 + (1-1)^2 + (0-0)^2 + (0-0)^2 + (1-1)^2 + (1-1)^2 + (0-0)^2 + (0-0)^2 + (1-1)^2 + (1-1)^2 + (0-0)^2 + (0-0)^2 + (1-1)^2 + (0-0)^2 + (1-1)^2 + (1-1)^2 + (0-0)^2 = 0$$

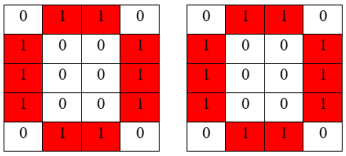

Figure 11. Input Patterns and Pattern Templates

3. Results

1. Results of the Fuzzy Mamdani Implementation Test on the Mirror Tracer Application

The process of calculating Fuzzy Mamdani in this study is used to determine the level of mental resistance conditions based on the length of time to draw the pattern, and the number of error points. The following is a picture of time input and the number of error points obtained after the user draws a pattern at the easy level.

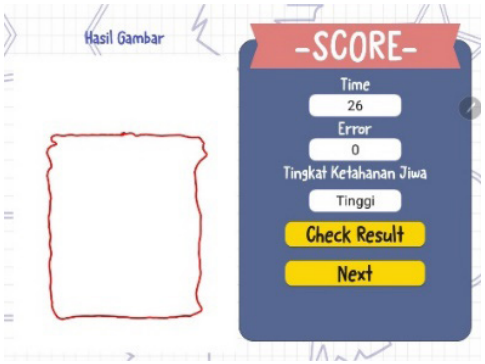

Figure 12. Score results using Fuzzy Mamdani

In Figure 12. The result of Fuzzy Mamdani calculation is "High", obtained from IF Time is Maximum and Few Error, then the results of the level of mental resistance conditions are Fair.

2. Results of Testing the Matching Template Implementation on the Server

Figure 13 shows the results of the input on the server after the user sends data from a smartphone device.

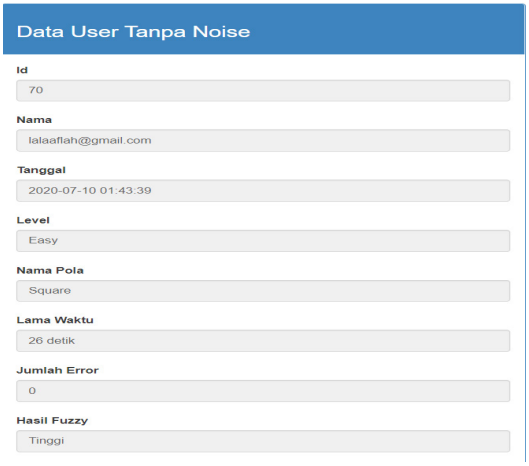

Figure 13. Results Input data from the application to the server

The template matching process in the research is run on the server, after the user presses the Continue button when calculating the Fuzzy Mamdani data name, time, number of error points, level, the result of the condition of the mental endurance condition, and the results of the image was sent to the server using the rest server for the history process.

Figure 14. Results Input data from the application to the server

Then the psychologist pressed the check tracing button in Figure 14. To run the pattern matching process use the Template Matching method by displaying the input image path with the template image as in Figure 14.

After pressing the submit button, it displayed the percentage difference between the input pattern and the template pattern in Figure 16.

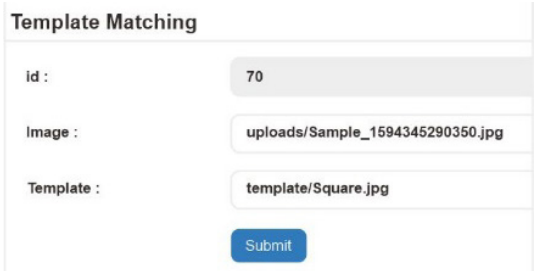

Figure 15. Template Matching Process

Figure 16. Pattern Match Percentage Results

The result is not suitable when the percentage result of pattern difference is too high. On the contrary, if the result of the pattern difference percentage level is low, the result is suitable.

4. Discussion

This discussion aims to obtain conclusions from the results of the tests carried out on the application of hybrid methods in the application of experimental psychology for the analysis of mental endurance conditions that have been carried out. The following is an example of a case study for calculating the level of mental endurance using the Fuzzy Mamdani method. The data used is the processing time parameter of 63 seconds with the number of errors 39 at the easy level. Figure 17 shows the output of the application.

Figure 17. Result of the Score of Mental Endurance Condition Level

In Figure 17, the score for the level of mental resilience is "Less", the score is less obtained from 4 Calculation Steps for Fuzzy Mamdani as follows.

The first stage in Fuzzy Mamdani is to find the Fuzzy Set in the form of membership degrees in the time variable and the number of error points. The maximum value for Maximum Time set is 120 (seconds), and Minimum Time set is 420 (seconds). Time = 63 is in the Maximum and Fast Time area as shown in Figure 18.

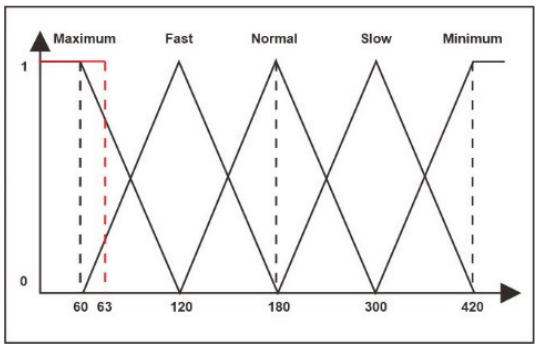

Figure 18. Graph of Easy Time Variable Membership Functions

At the number of points of error, the maximum value for the "Few" set is 16, and the "Lots" set is 32. The number of error points (Error) 39 is in the "Lots" membership area – shown in Figure 19.

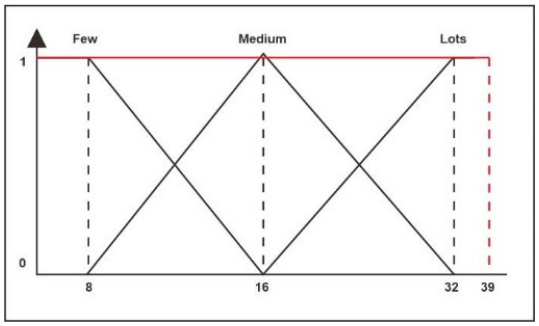

Figure 19. Graph of Variable Membership Functions Number of Easy Error Points

Then, we calculate the value of the degree of membership in the "Maximum" time variable in order to find the value of the intersection as in Figure 20.

$$\mu\text{MaximumTime [63]} = \frac{120-63}{120-60}, 60 < x < 120$$
$$= \frac{57}{60}$$
$$= 0{,}95$$

$$\mu\text{FastTime [63]} = \frac{63-60}{120-60}, 60 < x < 120$$
$$= \frac{3}{60}$$
$$= 0{,}05$$

Then, to calculate the value of the degree of membership in the variable number of error points in order to find the many value as in Figure 21.

Figure 20. Calculation Results of Fuzzy Sets on Time Variables

$$\mu\text{Multiple Point of Error [39]} = 1, 39 \geq 32$$
$$= 1$$

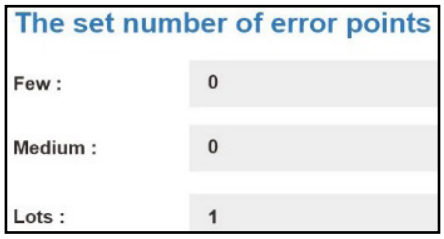

Figure 21. Calculation Results of Fuzzy Sets on the Variable Number of Error Points

Then, the second step of Fuzzy Mamdani is the Implication Function process in Table 4 rule which is used to find the *Min* value in Figure 22 found in the following rule:

[R11] *IF* Maximum Time *AND* Lots Error *THEN* Levels of Mental Endurance Condition is Average

$$\alpha\text{Predicate6} = \mu\text{MaxTime} \cap \mu\text{LotsErrors}$$
$$= \min(\mu\text{MaxTime}(630) \cap \mu\text{LotsErrors}(39))$$
$$= \min(0{,}95 ; 1)$$
$$= 0{,}95$$

[R12] IF Fast Time AND Lots Error THEN Levels of Mental Endurance Condition is Fair

$$\alpha\text{Predicate6} = \mu\text{FastTime} \cap \mu\text{LotsErrors}$$
$$= \min(\mu\text{FastTime}(63) \cap \mu\text{LotsErrors}(39))$$
$$= \min(0{,}05 ; 1)$$
$$= 0{,}05$$

After finding the Min Implication value, then the third step of Fuzzy Mamdani is conducted – looking for the Rule Composition by determining the Max value first from the value that has been obtained from the Min implication as in Figure 23.

Max Fair level = 0 max(0 ; 0)
Max Average level = 0,95 max(0,95 ; 0,05)
Max Less level = 0 max(0,0 ; 0,0)

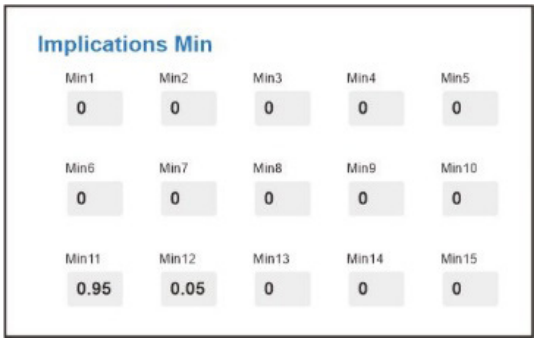

Figure 22. Results of Min Implication Functions of Each Rule

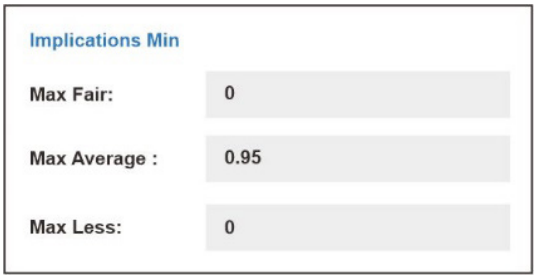

Figure 23. Max Implication Results on Rule Composition

After determining the max value, then calculating the composition of the rules from the max value by finding the z value as follows:

At a $\mu_{moderatelevel}(x)$ z value can be determined as follows:

$$0{,}95 = \frac{(70 - z)}{70 - 50}$$
$$19 = z - 70$$
$$z = 89$$

The following Figure 24 is an implementation of the composition of rules on the server:

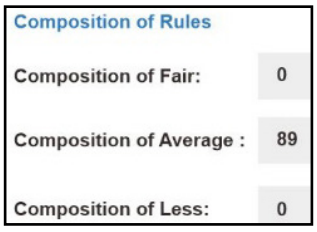

Figure 24. Rule Composition Results

Then, the fourth step of Fuzzy Mamdani is defuzzyfication in the fuzzy inference system which changed the output of the fuzzy set from stage 3 with the input of a set obtained from the composition of fuzzy rules into a number in the domain of the fuzzy set. The numbers obtained from the defuzzyfication process were presented in the form of levels of mental resistance conditions including Fair, Average, and Less.

$$x^* = \frac{((0 * 0) + (89 * 0{,}95) + (0 * 0))}{(0 + 0{,}95 + 0)} = \frac{84.55}{0.95} = 89$$

The following Figure 25 is an implementation of defuzzification on the server:

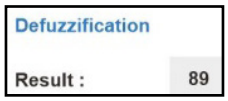

Figure 25. Defuzzification Results

The value of 89 is included in the Less range, so it can be concluded that the level of the condition of mental endurance based on the time variable is 63 seconds, the number of error points is 39, and the level of the condition of mental endurance is Less.

After the score results in the application have been determined, then match the input image with the template image on the server using the Template Matching method by clicking the check tracing button, the server displayed a page to display the path of the input image file and the template image as shown in Figure 26.

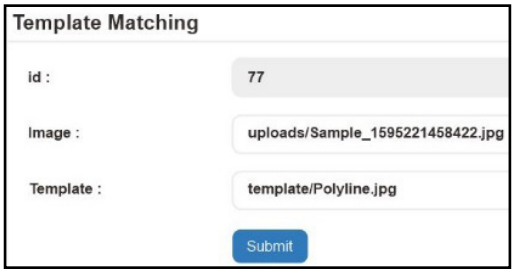

Figure 26. Matching Input Images to Templates

After pressing the submit button, it displayed the percentage difference between the input pattern and the template pattern, shown in Figure 27.

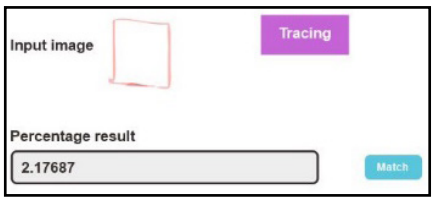

Figure 27. Matching Template Percentage Results

The percentage result is that the higher the pattern difference percentage level, the result is not suitable, on the contrary, if the result is the lower the pattern difference percentage level, the result is suitable.

In the application of the Hybrid Method in the Experimental Psychology Application for the Analysis

of the Conditions of Mental Endurance, the User Acceptance Test (UAT) was tested using a questionnaire. User Acceptance Testing (UAT) is a very innovative methodology to prevent IT project failures [13]. Based on the Usability test using the questionnaire in Table 5 and Table 6 by answering the questions given were calculated by calculations in accordance with the formula [8]:

$$U = \frac{Observation\ Score}{Expected\ value} x\ 100$$

note:
P = The number of respondents' answers to each question
Q = Expected value
U = Percentage Value

In the User Acceptance Test (UAT) questionnaire, there are 5 answer choices, namely SS (Strongly Agree) with a score of 5, S (Agree) with a score of 4, CS (Adequately Agree) with a score of 3, KS (Less Agree) with a score value 2, TS (Disagree) with a score of 1.

The following is the result of calculating the percentage of the UAT Test on a Psychologist:

Table 5. Psychologist Percentage Calculation Results

No.	Question	Percentage
1	In your opinion, is the mirror tracer application's appearance as expected?	80%
2	In your opinion, is the pattern drawing feature in this mirror tracer application complete?	70%
3	In your opinion, is the process of drawing on the canvas in this mirror tracer application as desired?	70%
4	Is the shape of the pattern on the canvas according to the level division?	80%
5	Are the timer and number of error points running as desired?	80%
6	Do you think that you have trouble starting the mirror tracer application?	50%
7	Are the features contained in the mirror tracer application easy to understand?	80%
8	Are the timer menu and the number of error points in this mirror tracer application running according to its function?	80%
9	Can this application help to psychological test the mirror tracer tool?	80%
Average		83%

The following is the result of calculating the percentage of the UAT Test on Prospective New Employees:

Table 6. Results of Percentage Calculation of Prospective New Employees

No.	Question	Percentage
1	Do you think the psychological test is important when applying for a job?	95%
2	Do you think the mirror tracer application can help to psychological test the mirror tracer tool?	92%
3	Do you think the mirror tracer application can determine the state of life endurance?	97%
4	When doing a psychological test on the mirror tracer tool, do you find it difficult?	47%
5	Do you think the shape of the pattern affects the level of difficulty during the psychological test?	91%
6	Does the selection of the decisive level can determine different test results?	91%
7	Do you think the sound of the oxytron during drawing relaxes you?	99%
8	Do you think that loud music during the distraction process can interfere with concentration?	98%
9	Do you think the results of the length of time worked can affect the results of the level of mental resistance conditions?	95%
10	Do you think the number of points of error can affect the outcome of the state of endurance level?	94%
11	After trying the Mirror Tracer application, do the test results match your mental endurance character?	94%
12	Is this application easy to use / user friendly?	97%
13	Is the opening display in the mirror tracer application interesting?	100%
14	Is the mirror tracer application's canvas pattern interesting?	96%
15	Does the display of the score menu on the mirror tracer application help find out the results of the level of mental endurance conditions?	97%
Average		92%

5. Conclusion

Based on the results and discussions that have been carried out, it can be concluded that the application of experimental psychology implementation has been able to implement the mirror tracer tool for psychological tests in recruiting new employees, namely displaying the results of the level of mental endurance using Fuzzy Mamdani calculations with the variable length of time and the number of error points, then displays the percentage of matches between the input pattern image and the template image using the Template Matching method. Also, after testing the application of psychologists, getting a percentage of 83% agreed that the application could be used as an alternative test tool. And the results of testing applications for prospective new employees get a percentage of 92% agreeing that the application can be used to determine the condition of life endurance.

For further development, it can be conducted on the data management aspect of the new marker template by psychologists in real time. Given the limitations of the application that is made in the form of a static marker. The improvements can also be made to the use of other algorithms. Hence, the performance comparisons and analysis results can be carried out in order to earn better results.

Acknowledgement

Our gratitude goes to the students of the Information Technology Department, State Polytechnic of Malang. Especially to the UPT Research and Community Service (UPT PPM) Polinema which has provided assistance for the implementation of this research.

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khazanah informatika

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Speech Classification to Recognize Emotion Using Artificial Neural Network

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Abstract-This study seeks to identify human emotions using artificial neural networks. Emotions are difficult to understand and hard to measure quantitatively. Emotions may be reflected in facial expressions and voice tone. Voice contains unique physical properties for every speaker. Everyone has different timbres, pitch, tempo, and rhythm. The geographical living area may affect how someone pronounces words and reveals certain emotions. The identification of human emotions is useful in the field of human-computer interaction. It helps develop the interface of software that is applicable in community service centers, banks, education, and others. This research proceeds in three stages, namely data collection, feature extraction, and classification. We obtain data in the form of audio files from the Berlin Emo-DB database. The files contain human voices that express five sets of emotions: angry, bored, happy, neutral, and sad. Feature extraction applies to all audio files using the method of Mel Frequency Cepstrum Coefficient (MFCC). The classification uses Multi-Layer Perceptron (MLP), which is one of the artificial neural network methods. The MLP classification proceeds in two stages, namely the training and the testing phase. MLP classification results in good emotion recognition. Classification using 100 hidden layer nodes gives an average accuracy of 72.80%, an average precision of 68.64%, an average recall of 69.40%, and an average F1-score of 67.44%.

Keywords: emotion, speech, MFCC, python, multilayer perceptron

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1. Introduction

Emotions are psychological fluctuations that develop in a person to respond to internal or external stimuli. Emotion is part of the human body that comes out into expression [1. Emotions are very difficult to measure from a quantitative viewpoint [2]. According to [3], there are five basic types of emotions, namely anger, happiness, sadness, fear, and disgust, which are not easy to measure. Emotion is typically accompanied by physiological and behavioral changes in the body. Emotion may appear in facial expression and voice speech. When a person's emotion changes, his facial expression changes. Therefore, the face is a good probe to measure emotional state. Detecting emotion in speech is more complicated. Speech contains both emotional information and linguistic messages. Voice is a characteristic of a person. Voice is a form of someone's expression of a situation. Everyone's voice has different vocals, rhythms, tempo, and stress. The difference in the characteristics of a person's voice is influenced by the language spoken and the area of residence.

Human emotion recognition or Speech Emotion Recognition (SER) is an active research topic [4]. The identification of human emotions is useful in the field of human-computer interaction. It helps develop the interface of software that is applicable in community service centers, banks, and education and others. The main component of emotion recognition is feature extraction and classification [5]. Selection of the right feature extraction algorithm is the main focus of SER activities. In turn, a suitable classification algorithm allows producing optimal emotional recognition.

Research on sound extraction of speech has recently focused on prosodic and spectral features. The observed characteristics include the pitch of the voice, length of sounds, loudness, and timbre. A study to recognize human

voice speech emotions used Hidden Markov Model (HMM) to analyze the pitch, energy, and formant [5]. Another research extracted energy feature, pitch, ZCC, and entropy and examined the extracted measure using the Mel Frequency Cepstrum Coefficients (MFCC) and the K-Nearest Neighbor (KNN) classification [6]. Research by [4] used MFCC feature extraction and Modulation Spectral Features (MSFs) and analyzed the result using Multivariate Linear Regression (MLR) and Support Vector Machine (SVM).

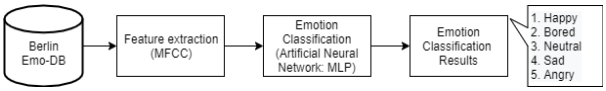
Several SER studies used available databases as datasets in emotion classification. [5] used HMM algorithm and a database of recorded sound film to recognize angry, happy and neutral emotion. [7] used the Berlin Emo-DB database to create an emotion recognition system employing MFCC and SVM. [8] compared the accuracy of three databases: Berlin Emo-DB, SAVEE, and TESS in recognizing emotions. Eventually, [9] developed a real-time emotion recognition system using the RAVDESS and SAVEE databases as input to the training module.

This paper discusses the results of research on speech classification for emotion recognition. The research attempts to identify human emotions in speech using the Berlin Emo-DB emotion database. The study uses the MFCC method for feature extraction and uses the Artificial Neural Network's Multi-Layer Perceptron (MLP) method for emotional classification. MFCC method finds a good application in Emotion Recognition Systems. MFCC is superior for speaker identification and emotion recognition because its work similarly resembles how the human ear works [7]. On the other hand, the MLP method is suitable to carry out a directed learning process for pattern recognition [10].

The research utilizes the Scikit-Learn module on the Python programming language platform. Scikit-learn integrates various machine learning algorithms for supervised and unsupervised learning problems [11]. The module facilitates the study in speech processing and recognition. The research has assumed that the module can produce good speech recognition. The study has continued the previous works that have been reported elsewhere [12]. Further study is possible that examines various methods of feature extraction and classification or adding other feature extraction and classification methods [13].

2. Methods

The process of recognizing speech emotions for classification of emotions in this study follows the stages presented in Figure 1. The most important main processes are feature extraction and classification. The results of feature extraction are very influential in determining the results of the recognition of speech emotions at the classification stage. The data used in this study are speech sounds stored in the Berlin Database of Emotional Speech Berlin Emo-DB. The features of the sound samples from the database were extracted using the spectral method, namely MFCC. The results of feature extraction are used in the classification process using Artificial Neural Networks with the Multi-Layer Perceptron model.



Gambar 1. Research Flow

a. Emotion Database

The data used in this study uses the Berlin Database of Emotional Speech Berlin Emo-DB is a part of a DFG SE462 / 3-1 research project in 1997 and 1999. The project director is Prof. Dr. W. Sendlmeier from the Technical University of Berlin, Institute of Speech and Communication, Department of Communication Science. The project members include Felix Burkhardt, Miriam Kienast, Astrid Paeschke, and Benjamin Weiss [14].

The emotions in this database are anger, boredom, disgust, fear, happiness, sadness and neutrality. The recording of the database creation was carried out in the anechoic room at the Technical University of Berlin, Department of Technical Acoustics. Actors were selected through a selection that resulted in 10 actors. The choice of sentences for pronunciation was also considered in the creation of this database. The spoken sentence is a normal sentence that is used everyday. This selection is useful so that the actor can pronounce it naturally without making up. This database contains about 500 samples that have a level of recognition of human emotions that is assessed according to the results of the study [14].

This study only took five types of emotions, namely anger, boredom, happiness, neutrality, and sadness, which were said by ten different actors. The study used 420 emotional data consisting of 127 data of angry emotions, 81 data of bored emotions, 71 data of happy emotions, 79 data of neutral emotions, and 62 data of sad emotions. All audio data is extracted from the Berlin Emo-DB. The audio data file provided by Berlin Emo-DB has an uneven number of emotions.

b. Feature Extraction

Determination of feature extraction is the most important stage in the recognition of speech emotions. A good extraction process can distinguish different feature patterns from one emotion class to another. The extraction of emotional features can be divided into three categories, namely prosodic features, spectral features, and sound quality features [15]. Prosidis features include frequency, duration, energy, pitch, and formant. Spectral features include LPC (Linear Predictive Coding), LPCC (Linear Predictor Ceptral Coefficients), MSF (Modulation Spectral Feature), MFCC, ZCPA (Zero Crossings with Peak Amplitudes), and others. Sound quality features include frequency and bandwidth formats, shimmer, jitter and more. The results of feature extraction are further

processed to obtain statistical values such as max, min, mean, median, kurtosis and skewness [16]. The statistical value can be used for the classification process.

MFCC is a parametric representation of speech signals applied to speech speech recognition and is becoming popularly used for voice identification and emotion recognition [7] [17] [18] [19]. By applying cepstral analysis, MFCC tries to mimic the workings of the human hearing organ [19] [20]. MFCC is a coefficient representing perceptual sound with logarithmic frequency bands that mimic human vocals [21]. According to [13] the most commonly used number of coefficients is the coefficient of 20, the use of a coefficient of 10-12 is considered sufficient depending on the spectral shape. Research [22] on speech recognition uses a factor of the number of coefficients between 9 and 13, and research [19] uses a number of coefficients of 13. The results of feature extraction are then searched for statistical values such as mean, STD, max, min, kurtosis, skewness, and median. 16]. The aim is to reduce the value obtained from the MFCC extraction process [21].

c. Emotion Classification Using Artificial Neural Networks: Multi-Layer Perceptron (MLP)

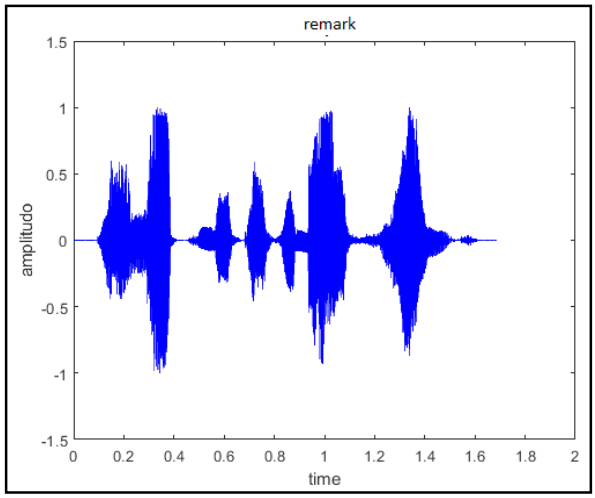
Emotion classification is an important step in recognizing emotions according to each emotion class. The Multi-Layer Perceptron is a feedforward network model consisting of several neurons connected by neuron connecting weights [23]. The neurons are arranged in a layer consisting of an input layer, one or more hidden layers, and an output layer [24]. The MLP learning process updates the return weight (backpropagation). This weight update is carried out to find the most optimal value to produce the correct classification results.

The MLP classification process is divided into two stages, namely the training stage and the testing phase. These two stages are carried out on different data, namely dividing the research data into two, namely training data and testing data. The training stage is carried out for network initialization and formation, namely to determine the number of input layers, hidden layers, and output layers. During the training phase, parameters such as learning rate, number of iterations, and error threshold were determined. The training stage uses a lot of data to produce a good classification pattern. The testing phase is carried out to find out the classification results that have been made at the training stage whether it provides correct and accurate classification results.

3. Result

a. MFCC Feature Extraction

Figure 2 shows an example of a voice signal which is the raw data in this study, namely data that has not gone through feature extraction. The signal is a typical wave of angry emotional signals uttered by an actor. The horizontal axis on the graph is time and the vertical axis is the power of sound (amplitude).



Gambar 2. An example of data is in the form of a voice signal

Data as in Figure 2 is processed using MFCC with a coefficient of 13. The process of feature extraction is carried out using modules from the Python programming language [25]. The results of feature extraction are processed to determine the mean value which in turn is used for the classification process of angry, bored, happy, neutral, and sad emotions using the MLP method. The value of the MFCC feature extraction results for some voice data can be seen in Figure 3. The extraction results for each data signal are 13 numbers, which are the MFCC coefficient.

```
(coba1) C:\Users\miya\Downloads\emo\MLPC>python mlpc_mfcc.py
[-231.60624695   92.5904007   -65.33570862   36.0592308   -22.75979424
   11.20137024  -17.49736214   -4.46751213  -14.95390701   -4.57388735
    0.2414781    -9.82732201    2.41696286]
[-2.37015228e+02  8.18815994e+01 -5.37225342e+01  5.49401703e+01
 -2.63500481e+01  2.28200436e+01 -2.17195854e+01  5.84484673e+00
 -2.18916855e+01 -1.55605440e+01 -2.06271482e+00 -9.87513638e+00
 -9.88514349e-02]
[-265.32177734   90.79400635  -66.16335297   38.79422379  -23.11333847
   13.02254677  -21.92616463   -6.57378626  -20.13197899  -15.61307812
   -5.08499956   -3.89514422    0.67546362]
[-256.14828491   80.34231567  -53.94718933   28.85256195  -34.49461365
   12.99799156  -17.36316109   -5.11837339  -12.10678673  -15.38851166
   -3.58391213   -4.98516273   -5.83383417]
[-244.81404114   83.03751373  -43.65733719   44.02210617  -22.54923058
   10.78010368  -18.32955551   -0.70485991  -17.43508339   -9.00274086
    3.73999429  -10.37380695    0.72797906]
```

Gambar 3. MFCC Feature Extraction for 5 voice data samples

b. Emotion Classification

This study uses 420 emotional data, with 127 data on angry emotions, 81 data for bored emotions, 71 data for happy emotions, 79 data for neutral emotions, and 62 data for sad emotions. Each emotional speech data is processed using MFCC with a coefficient of 13 to get the feature extraction value. From the results of feature extraction, the mean value is determined which is used as input in the artificial neural network using the Multi-Layer Perceptron model. The output of the artificial neural network is five classes of emotions, namely anger, boredom, happiness, neutrality, and sadness. The parameters used in the MLP model can be seen in Table 1. There are three layers used, namely the input layer, one hidden layer, and the output layer. The input node is connected to the MFCC feature

extraction result coefficient 13 and the output node is five emotion classes.

Tabel 1. MLP Method Emotion Classification Parameters

Parameter	Value
Learning rate	0.0001
Error threshold value (epsilon)	1e-08
Epoch	1000
Cross Validation	5 folds
Layer	3 layer
Node input	13
Node Hidden Layer	10
Node output	5

Observations regarding classification performance require training data and test data. Training and testing data were obtained by dividing 420 existing data with a comparison of 80% of data for training and 20% of data for testing. Validation of the performance of the classification process was carried out by using five-fold cross validation. The data presented next is the average of the performance for each fold. Tests were carried out for various numbers of hidden layer nodes. The test results for the number of different hidden layers are presented in Tables 2-6.

Tabel 2. Test Results with Hidden Layer Node = 10

Emotion Class	Accuracy	Precision	Recall	F1-Score	Total
Angry	61.00	84.20	88.40	86.20	32
Bored	68.00	46.20	44.60	45.00	17
Happy	64.00	44.20	36.00	39.60	10
Neutral	62.00	43.00	48.00	45.00	15
Sad	65.00	77.20	72.00	74.40	10
Macro averaged	64.00	58.96	57.80	58.04	84

Table 2 shows that the average accuracy of emotion recognition is 64%, the average precision is 58.96%, the average recall is 57.80% and the average F1-score is 58.04%. The addition of a hidden layer to 30 results in a better classification. Table 3 shows a significant increase in accuracy value to 68%. The same increase occurred for precision and recall so that the F1 score was bigger at 62.84%.

Tabel 3. Test Results with Hidden Layer Node = 30

Emotion Class	Accuracy	Precision	Recall	F1-Score	Total
Angry	74.00	85.20	91.00	88.00	32
Bored	67.00	50.40	43.40	46.20	17
Happy	68.00	50.20	40.00	44.40	10
Neutral	67.00	51.80	57.20	54.20	15
Sad	67.00	79.20	84.00	81.40	10
Macro averaged	68.60	63.36	63.12	62.84	84

Test Results with Hidden Layer Node = 50

Emotion Class	Accuracy	Precision	Recall	F1-Score	Total
Angry	75.00	86.00	85.80	86.00	32
Bored	74.00	58.80	51.80	55.00	17
Happy	64.00	42.40	40.00	40.60	10
Neutral	73.00	58.80	63.80	61.00	15
Sad	64.00	80.60	90.00	84.80	10
Macro averaged	70.00	65.32	66.28	65.48	84

An increase in classification performance was also seen when the number of hidden layer nodes was increased to 50 (see Table 4). Accuracy increased by 1.4 points compared to the classification with 40 hidden layers (Table 3). Meanwhile, the F1-score increased by more than 2.5 points. This shows that the use of the number of hidden layers of 50 significantly results in a better classification than the number of hidden layers of 40. When the number of hidden layers is increased to 80, there is no increase in the performance of the previous classification (see Table 5). The addition of a hidden layer of 30 new nodes only increased accuracy by 1.8% and increased the F1-score by 1.6%.

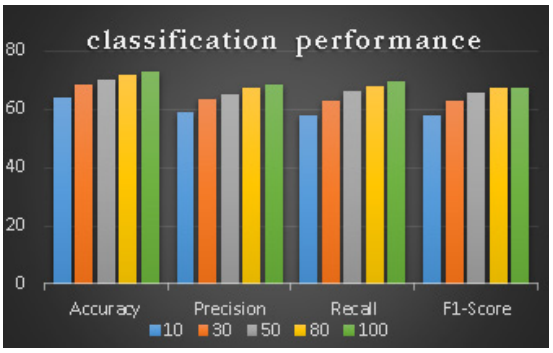
Tabel 4. Test Results with Node Hidden Layer = 80

Emotion Class	Accuracy	Precision	Recall	F1-Score	Total
Angry	76.00	86.80	89.00	87.80	32
Bored	75.00	59.60	47.00	52.20	17
Happy	71.00	48.60	44.00	45.60	10
Neutral	69.00	60.40	70.60	65.00	15
Sad	68.00	80.40	90.00	84.80	10
Macro averaged	71.80	67.16	68.12	67.08	84

Test Results with Hidden Layer Node = 100

Emotion Class	Accuracy	Precision	Recall	F1-Score	Total
Angry	77.00	85.80	91.00	88.20	32
Bored	67.00	64.40	48.00	52.20	17
Happy	68.00	56.20	42.00	47.20	10
Neutral	77.00	62.20	72.00	66.40	15
Sad	75.00	74.60	94.00	83.20	10
Macro averaged	72.80	68.64	69.40	67.44	84

Testing the MLP model using 100 hidden layer node further improves the emotional classification results (see Table 6). However, the improvement is not sufficiently significant compared to the effort to add such a large number of hidden layer nodes. The accuracy score is 72.8% and it is just 2.8% higher than the accuracy for the 50 hidden layer nodes (see Table 4). The F1-score has increased to 67.44, which means that it is 1.96% higher than that for the 50 hidden layer nodes. The increase in the accuracy, precision, recall and F1-score for all observations with various numbers of hidden layers is presented in Figure 4. The figure confirms a significant increase for various metrics when the hidden layer nodes were increased from 10 to 50. Subsequently, the increase becomes sloping and insignificant when the hidden layer is increased to 80 and to 100. The figure probably suggests that the use of the MLP model is optimal when the number of hidden layers is around 50.



Gambar 4. Testing Comparison Chart

If we look more detail into the recognition results for each type of emotion, the results show different numbers in the accuracy value and F1-score. In the F1-score measurement, the score tends to be high for the recognition of angry and sad emotions. Trends are consistent for MLP models with varying numbers of hidden layers (see again Table 2-6). The F1-score for the recognition of angry emotions was always above 86%, while the recognition for sad emotions ranged from 74% to 84.8%. The recognition of happy emotions shows the lowest F1-score, which is below 50%. Emotion recognition performance measurement using accuracy shows variable metric values and is less consistent when the number of hidden layers is increased. When the number of hidden layers is 10, the highest accuracy value is reached for the recognition of bored emotions. However, when the number of hidden layers was increased to 30, the highest accuracy value was reached for recognition of angry and happy emotions. Furthermore, when the number of hidden layers is between 50 - 80, the highest accuracy value is reached for the introduction of angry and bored emotions. Meanwhile, the model with the number of hidden layers of 100 produces emotion recognition with the highest accuracy for angry and neutral emotions.

The recognition of emotions in this study resulted in better accuracy than the previous study [12] which was only 31.67%. This research proves that the greater the number of hidden layer nodes, the better emotion recognition is. However, the optimal number of hidden layers still needs to be examined in terms of the computation time associated with the acquisition of metric values. This study also noted that the accuracy of emotion recognition varies for the types of emotions identified.

4. Conclusion

In this research, the speech classification process for recognizing emotions starts with feature extraction, which significantly affects the result of emotion recognition. We use Mel Frequency Cepstrum Coefficients (MFCC) for the feature extraction. The next step is emotion classification that uses an artificial neural network called Multilayer Perceptron (MLP). The method produces good speech emotion recognition as indicated by the classification performance measure. In general, the performance measure steadily improves with the increase of the number of hidden layers from 10, 30, 50, 80 to 100. The accuracy attains the highest score of 72.8 when the number of hidden layers is 100. Likewise, the F1-score is at its highest value of 67.44 for the same number of hidden layers. The accuracy of the emotion recognition varies with the varying number of nodes. The F1-score is more consistent in measuring the performance of emotion recognition. Referring to the F1-score value, the model performs better in recognizing angry and sad, but it performs poorly in recognizing happy emotions.

Acknowledgement

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Classification of Pandavas Figure in Shadow Puppet Images using Convolutional Neural Networks

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Abstract-Indonesia is a nation with various ethnicities and rich cultural backgrounds that span from Sabang to Merauke. One of the cultural products of Indonesian society is shadow puppet. Shadow puppet has been internationally renowned as a masterpiece of cultural art and recognized by UNESCO. The development of Indonesian society is very dependent on technological sophistication and it may shift the existing traditional culture out from the memory of the nation. Practices of modern life and the busy activities of the people exacerbate the condition and may make the society to ignore traditional culture. This study seeks to preserve traditional Indonesian culture by making shadow puppets as the object of classification. We use a deep learning algorithm called convolutional neural network (CNN) to classify 430 puppet images into 4 classes. The proportion of training, validation and test data is 70 by 20 by 10. The experiments show that the most efficient model is obtained with 3 convolution layer. It reaches an accuracy rate of 0.93 and a drop out rate of 0.2

Keywords: shadow puppet, pandavas, image classification, deep learning; convolutional neural network

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1. Introduction

The Indonesian nation is a nation that has various ethnic and cultural backgrounds from Sabang to Merauke. One of the cultural products of Indonesian society is shadow puppet. This art developed on the islands of Java and Bali. There are two versions of shadow puppet, namely wayang orang and wayang kulit. Wayang orang is a puppet that is played directly by people using costumes as their trademark, while the puppet in the form of a puppet is a puppet played by the puppeteer. Some of these puppet-shaped puppets include shadow puppets, puppets and grass puppets. Wayang kulit is a shadow puppet performance art made from dried animal skins originating from Central Java and Yogyakarta. The stories in puppet shows usually come from the Mahabharata and Ramayana which have been changed by poets and masters in the archipelago [1].

In the international world, shadow puppet has now been recorded as a masterpiece of cultural art, namely by UNESCO, an institution under the United Nations that deals with issues of education, science and culture. On 7th November 2003 the Indonesian shadow puppet was announced by UNESCO as a world masterpiece in Paris. This demonstrates that shadow puppetry, as a traditional cultural heritage, has been recognised internationally as a cultural heritage rich in values that contributes significantly to the creation and growth of national identity [2]. Seeing this award, as citizens with integrity, they should protect and preserve this culture. However, along with the times with increasingly sophisticated technological advances, shadow puppet shows are now increasingly being marginalized from the arena of the entertainment scene. The knowledge of this shadow puppet art among teenagers is decreasing, one of which is the ignorance of the puppet characters. This is because many puppet characters have different shapes and characters.

The many types of shadow puppet in Indonesia make researchers interested in creating a program to recognize the type of wayang kulit, especially for Pandavas figure based on a dataset of photos or shadow puppet images. The introduction of the shadow puppet image will later be classified according to the five types of pandavas figure that exist. Seeing the development of an era in which Indonesian society is very dependent on technological sophistication, it is possible if the existing culture begins to be forgotten. Habits of modern life and the daily activities of the people also make it possible for traditional culture to be forgotten. Therefore, the selection of the shadow puppet object in this

study is expected to be able to contribute to the preservation of Indonesian culture. In this case, the data collection of shadow puppet objects will be classified according to their type using a computer program.

Researchers are currently focusing on the development of deep learning, especially the neural network process, since its output is superior to that of other methods. Several studies on convolutional neural network (CNN) have been conducted by previous researchers, with a test error of 17%, the ImageNet LSVRC-2010 dataset was divided into 1000 classes, yielding very important results in testing. [3]. Comparing the convolutional neural network (CNN) method with several other classification methods implemented for animal recognition, the result is that the CNN method gives the best results with an accuracy rate of up to 98% [4]. When the CNN approach is used to introduce road traffic signs, an accuracy rate of about 85 percent to 90 percent is achieved [5]. Based on the exposure of several studies above, it can be concluded that the use of the CNN method in classifying images has better advantages over other classification methods. The researcher chose the convolutional neural network (CNN) algorithm to identify the shadow puppet images for this purpose.

2. Method

a. Pandavas Figure

Figure 1. Pandavas Figure

One of the shadow puppet which is well known as shadow puppet culture in Indonesia is pandavas figure. Pandavas figure is one of the puppets originating from the Mahabharata story. There are five characters in the Pandava puppet, namely Yudistira, Bima, Arjuna, Nakula and Sadewa. Each pandavas figure in the shadow puppet, especially the Javanese version of the pandava, has a distinctive and meaningful character, the following are the characters in the Pandava puppet quoted from the internet [6]:

1) Yudistira

Puntadewa is the small word for Yudistira.He is the oldest of Pandu and Dewi Kunti's five sons, the Pandavas. He is Lord Yama's embodiment.The Kingdom of Amarta was ruled by Yudistira.Yudistira is a wise man who has no rivals and has rarely lied in his life. Has a high morale, enjoys forgiving and forgiving enemies who have given up. Fairness, tolerance, integrity, religious observance, self-assurance, and the willingness to speculate are some of the other qualities that stand out.

2) Bima

Sena is Bima's first name. Pandu and Dewi Kunti have a son named Bima. Since he is an embodiment of Dewa Bayu, he is known as Bayusutha. Bima is the most strong of his brothers, with long arms, a tall stature, and the most terrifying face. Despite this, he has a good spirit. When it comes to mace guns, you're a natural. Rujakpala is the name of the club's arms. Werkudara is another nickname for Bima. Bima has three children in Javanese puppetry: Gatotkaca, Antareja, and Antasena. Bima is a brave, steadfast, strong, steadfast, obedient, and honest character. Bima is also cruel and frightening to his rivals, despite the fact that his heart is tender. He has a single-minded attitude, dislikes small talk, is never ambivalent, and never licks his own saliva.

3) Arjuna

Permadi is Arjuna's first name. He is the youngest son of Dewi Kunti and Pandu. Lord Indra, the god of war, has come to life in him. He is a wise knight who enjoys wandering, meditation, and learning new things. Arjuna was a skilled archer and was regarded as a knight. His military prowess made him the Pandavas' rock in order to win the major fight against the Kauravas. Janaka is another name for Arjuna. In Madukara, he was the ruler. Arjuna is a clever, quiet, gentle, cautious, respectful, courageous warrior who enjoys protecting the helpless.

4) Nakula

Pinten is Nakula's nickname. Nakula is one of Dewi Madrim and Pandu's twin sons. He is the embodiment of Aswin, the god of medicine, who is one of the twin gods. Nakula is a master of the sword weapon. Nakula is the most attractive man on the planet and a formidable swordsman. Nakula's characters are trustworthy, faithful, and obedient to their parents. They also know how to repay favors and keep secrets.

5) Sadewa

Tangsen is Sadewa's nickname. Sadewa is one of Dewi Madri and Pandu's twin sons. He is the embodiment of Aswin, the god of medicine, who is one of the twin gods. Sadewa is a hardworking and wise person. Sadewa is an astronomy specialist as well. Sadewa's characters are trustworthy, faithful, and obedient to his parents. They also know how to repay favors and keep secrets.

The puppet dataset used in this study was taken from open sources via the website http://tokohwayangpurwa.blogspot.com/ [7] with a total of 418 images classified into 4 classes: Yudistira, Bima, Arjuna, Nakula Sadewa (second these figures are physically identical twins).

b. Deep Learning

Deep learning has recently become a hot topic in machine learning research. The explanation for this is that deep learning has shown incredible results in the field of computer vision. Deep learning is a branch of machine learning that makes use of neural networks to solve problems involving large datasets. For supervised learning, deep learning techniques have a very powerful architecture. The learning model will better reflect labeled image data by adding more layers.

There are strategies for extracting features from training data and special learning algorithms for classifying images and detecting sounds in machine learning. However, there are several disadvantages to this approach in terms of speed and accuracy. Convolutional neural network (CNN) is a deep learning system that addresses the shortcomings of the previous method. With this model, a number of independent parameters can be decreased, and input image deformations including translation, rotation, and scale can be treated [8].

The application of deep (multi-layered) artificial neural network concepts can be suspended on existing machine learning algorithms so that today's computers can learn at speed, accuracy, and at large scale. Deep learning was widely used in the science community and industry to help solve many big data issues, such as computer vision, speech recognition, and natural language processing, as this theory evolved. One of the key features of deep learning is feature engineering, which extracts useful patterns from data to make it easier for models to distinguish between classes. The most critical technique for achieving good results on predictive tasks is feature engineering. However, different data sets and data types necessitate different engineering approaches, making it difficult to understand and master.

CNN methods or convolutional neural networks are very good at identifying good features in the image to the next layer to shape non-linear hypotheses that can increase the complexity of a model in deep learning, CNN methods or convolutional neural networks are very good at finding good features in the image to the next layer to form non-linear hypotheses that can increase the complexity of a model [9].

c. Convolutional Neural Network

Convolutional neural networks, or ConvNets, are a type of neural network that processes data in the form of multiple arrays, such as a color image made up of three 2D arrays containing pixel intensities in three different colors. Convolutional neural networks (ConvNets) are a subset of artificial neural networks (ANNs) that are widely regarded as the most effective model for solving object recognition problems.

A convolutional neural network, in technical terms, has a trainable architecture that consists of several steps. Each stage's input and output are feature maps, which are a collection of arrays. A two-dimensional matrix, for example, is the input for a greyscale image. Each stage's output is a feature map containing the processing results from all points in the input image. Convolution, activation, and pooling are the three layers that make up each level.

Figure 2 depicts the design of a convolutional neural network in general, as used by LeCun [10]. In this example, CNN's input is a picture of a specific size. The convolutional stage is the first in CNN. Convolution is done with the aid of a kernel of a certain scale. The number of kernels used is determined by the number of features that are generated. This stage's output is then passed through an activation function, such as a tanh function or a Linear Unit Rectifier (ReLU). The output of the activation function then goes through a sampling or pooling operation. Depending on the pooling mask used, the pooling process produces an image that has been reduced in size.

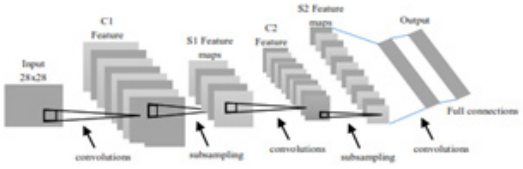

Figure 2. Convolutional Neural Network Architecture

1) Convolutional Layer

Neuron to (i, j) in the hidden layer, has a value of activity y which is calculated according to Equation (1), where the value (m, n) in the equation shows the size of the local receptive fields / kernel.

$$y_{ij} = \sigma(b + (w * x)) \quad (1)$$

$$(\mathrm{W} * \mathrm{x})_{ij} = \sum_{k=0}^{m} \sum_{l=0}^{n} w_{k,l} x_{i+j,k+l} \quad (2)$$

The multiplication between the input and the kernel above (Equation (2)) is usually called a convolution. However, convolution is carried out on an inverted kernel [11], as in Equation (3). Meanwhile, if the kernel is not reversed, the function is called cross-correlation. Even so, many machine learning libraries use the cross-correlation formula and call it the convolutional formula.

$$(\mathrm{W} * \mathrm{x})_{ij} = \sum_{k=0}^{m} \sum_{l=0}^{n} w_{k,l} x_{i-j,k-l} \quad (3)$$

The size of the convoluted image is reduced compared to the initial image and can be expressed by Equation (4). In this case, if an image with a size of 28x28 is subjected to convolution with a kernel size of 3x3 then the final size becomes 28-3 + 1 x 28-3 + 1 = 26x26.

$$ukuran_{hasilkonvolusi} = ukuran_{awal} - filtersize + 1 \quad (4)$$

Figure 3 shows an illustration of the convolution process in the image, which is a two-dimensional array I, with a weight of K (two dimensions) [12]. In this figure, a 4x3 image is convoluted using a 2x2 kernel. The resulting image is 3x2 in size. The first element in the convoluted

image is the sum of the multiplication of the kernel weight and the corresponding image value.

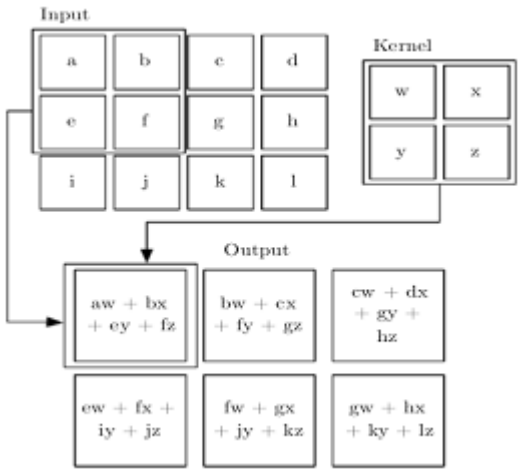

Figure 3. Convolution process on 2D array input with 2D weights

Via performance optimization, the convolutional layer is exposed to the model's complexity in a significant way. Three parameters, width, stride, and zero padding settings, are used to optimize this [13].

2) Pooling Layer

As convolution is performed, the pooling layer keeps the size of the data constant, i.e. by reducing the size of the matrix / sample reduction (downsampling) [14]. After the Convolutional Layer, the Pooling Layer is typically applied. The pooling layer is essentially a filter with a specific size and stride that alternately shifts the entire feature map region. In general, max pooling or average pooling are used in the pooling process. When using max pooling, the largest value is used, while when using average pooling, the average value is used. Of the two ways the pooling process is most often encountered is to use max pooling, for average pooling it is very rarely used but in several network architectures it can be found [15]. To monitor overfitting, a pooling layer inserted between successive convolutional layers in the CNN model architecture will gradually reduce the size of the output volume on the Feature Map, lowering the number of parameters and calculations on the network. Each feature map stack's size is reduced by the pooling layer, which runs on top of it. In most cases, the pooling layer employs a 2x2 filter that operates on each slice of the input in two stages. A max-pooling process is depicted in Figure 4.

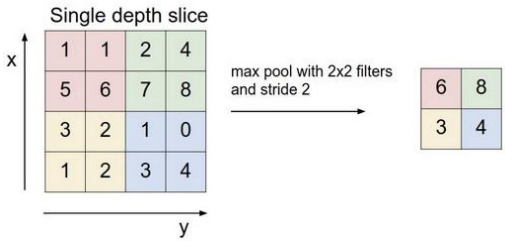

Figure 4. Max-Pooling Operation

The method of max-pooling is depicted in the diagram above. The pooling process produces a matrix with smaller dimensions than the original image. Each slice of the input volume depth will be processed by the pooling layer above. The max-pooling operation uses a 2x2 filter scale, as seen in the image above. The process's input is 4x4 in size; the maximum value is taken from each of the four numbers in the procedure input, and then a new output size of 2x2 is generated.

3) Normalization Layer

Normalization layer is useful for overcoming significant differences in value ranges. However, currently the normalization layer is still not widely used because the effect on this layer is not that big [14].

4) Fully Connected Layer

As with ordinary neural networks, the Fully Connected Layer is a layer in which all activation neurons from the previous layer are connected to all neurons in the next layer. This layer is most commonly used in MLP (Multi Layer Perceptron), which aims to convert data dimensions so that data can be categorized linearly.

The distinction between a fully connected layer and a regular convolutional layer is that the convolutional layer's neurons are only connected to a small portion of the input, while the fully connected layer's neurons are all connected. The two layers, however, still control the product dot, so their functions are similar.

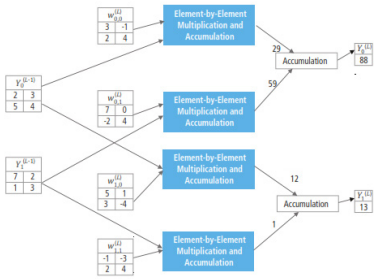

Figure 5. Processing of a Fully Connected Layer

5) The Activation Function

The activation function is a linear or non-linear function that defines the relationship between levels of internal activity (summation function). This role determines whether or not neurons are active. The ReLU (Rectified Linear Unit) activation function is one of the most widely used activation functions in CNN. The ReLU (Rectified Linear Unit) function basically performs a threshold operation from 0 to infinity. A graph of the ReLU activation function is shown below:

If the input from the neurons is a negative number, the function will convert that value to a value of 0, and if the input is positive, the neuron's output will be the activation value itself.

6) Loss Layer

Loss layer is the last layer in CNN where in this process it will show the predicted results and loss function values during the training process.

d. Dropout Regularization

Dropout is a regularization strategy for neural networks that prevents overfitting while also speeding up the learning process [16]. Overfitting is a situation in which almost all of the data that has gone through the training phase has reached a good percentage, but the prediction process has a gap [17].

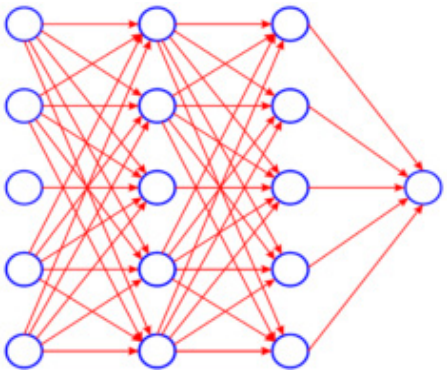

Figure 7. Standard Neural Net

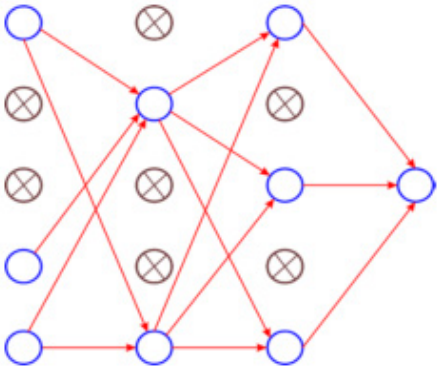

Figure 8. After Applying Dropout

Dropout refers to removing neurons that are either hidden or visible layers in the network. By removing a neuron, means removing it temporarily from the existing network. The neurons to be removed will be randomly selected. Each neuron will be assigned a probability p that is between 0.0 and 1.0 [18]. The dropout temporarily eliminates a neuron from the network in the form of a hidden layer or a visible layer in the working system. Figure 7 (a neural network with two hidden layers) and Figure 8 (a dropout process has been carried out) describes the dropout regularization process.

e. Adam Optimizer

Adam Optimizer is a way to optimize a parameter, this optimization can make the parameter to be a maximum or a minimum. Adam Optimizer is one of the optimizations that combines the AdaGrad and RMSProp methods [19].

f. Confusion Matrix

The accuracy matrix was used to test the model. To comprehend the matrix, true positive (TP), false positive (FP), false negative (FN), and true negative (TN) were previously specified as shown in Table 1's confusion matrix. Predicted positive data is classified as TP. True is characterized as negative data that is predicted to be true, while TN is defined as negative data that is predicted to be true. FN is the polar opposite of TP, which is negative data predicted to be incorrect, and FP is the polar opposite of TN, which is positive data predicted to be incorrect.

Table 1. Confusion Matrix

Predicted Class	True Class	
	Positive	**Negative**
Positive	True Positive (TP)	False Positive (FP)
Negative	False Negative (FN)	True Negative (TN)

The ratio of all correctly categorized data (both positive and negative) divided by the total number of data is known as accuracy. The formula for accuracy is Equation (5).

$$accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (5)$$

g. Research Flow

The flowchart in Figure 9 shows the procedure for classifying shadow puppet images using a convolutional neural network algorithm.

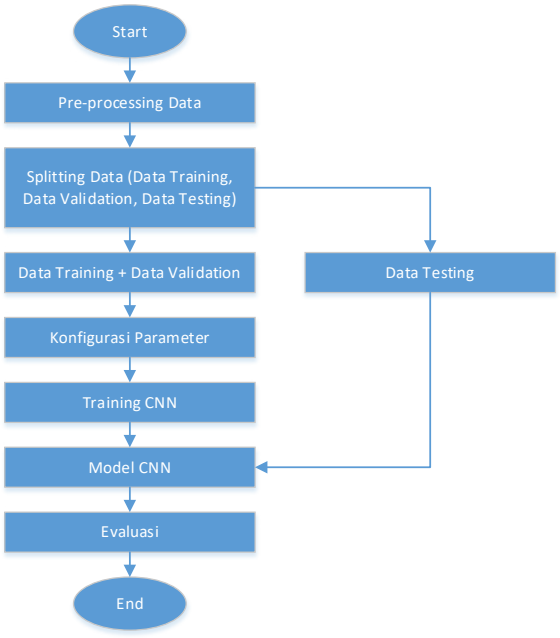

Figure 9. Research Flowchart

3. Result and Discussion

Using the Convolutional Neural Network (CNN) algorithm, the researcher categorized it into four image classes: yudistira (0), bima (1), arjuna (2), and nakula-sadewa (3). The training and data validation processes are

the most important steps in creating this model. The aim of this method is to construct a model that can detect the desired object with a high degree of accuracy.

Tests are carried out to see the effect of the depth of the convolution layer used on system performance by activating dropout regularization so that there is no overfitting due to too high an accuracy level or underfitting if the accuracy level is too low during the training process. The best-fit model would be used by the dropout regularization method, which has an effect on reducing noise data during the testing process, resulting in a high degree of accuracy. On a 46x46 pixel puppet image with 1-layer to 4-layer depth of convolution layers, this scenario is tested using 70% training data, 20% validation data, and 10% testing data.

The test results with the dropout regularization technique for each number of convolutional layers can be seen in Figures 10 to 13.

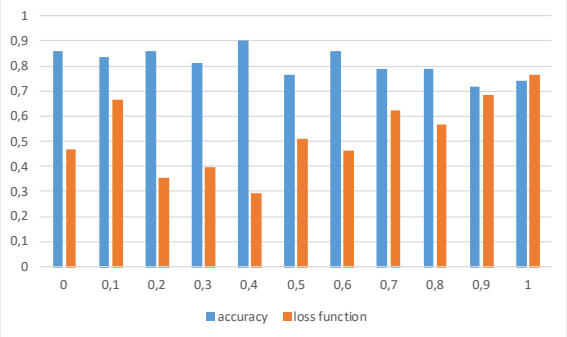

Figure 10. Adding a Dropout to a 1-Layer Convolution Layer

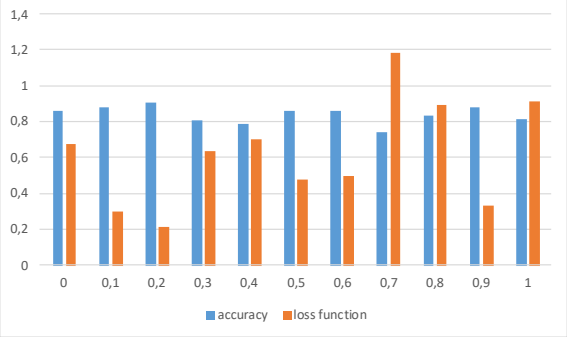

Figure 11. Adding a Dropout to a 2-Layer Convolution Layer

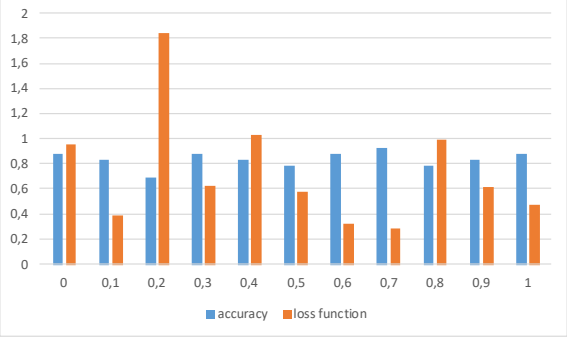

Figure 13. Adding a Dropout to a 4-Layer Convolution Layer

Based on the picture above, it can be analyzed that by using the dropout technique, the optimal accuracy rate is 0.93 with a loss function value of 0.197 in the 3-layer convolution layer, the dropout value is 0.2. Whereas in the 4-layer convolution layer the highest accuracy was also obtained at 0.93 with a loss function value of 0.291 dropout value of 0.7. Even though the accuracy value obtained is the same, the loss function value obtained in the number of 3-layer convolutions is smaller than the number of 4-layer convolutions, so the number of 3-layer convolutions was chosen as the best result in this study. Comparison of the level of accuracy obtained for each number of convolutional layers without adding a dropout (dropout = 0) with a dropout added can be seen in Figure 14. -layer) up to 0.88 (4-layer convolution) increases to 0.93 with a dropout value of 0.2.

4. Conclusion

With the addition of a 0.2 dropout in the number of 3-layer convolution layers, this study successfully implemented the convolutional neural network approach for the classification of shadow puppet images with the best accuracy percentage of 0.93 and loss function of 0.197. Of the 10% testing data, almost all have a match with existing training data. In the training process, the position and size of the images affect the accuracy and time of training data. The larger the size of the trained image, the longer the learning process, the inverted image position will affect the validity of the test results. The use of the number of layers in the training process also affects the level of accuracy in testing data. The more layers that are used, the better the results will be obtained, although it will have an impact on the length of the training process.

In the future, further research will combine convolutional neural network algorithms with several other methods to get better results. It is hoped that the existence of shadow puppets will be maintained by the classification of this shadow puppet image, namely by implementing it in an intelligent system application on a computer.

Acknowledgement

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khazanah informatika

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E-Prescription: Connecting Patients' Prescriptions with Pharmacists and Cashiers

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Abstract-The paper describes the development of an electronic prescription system. Electronic prescription or e-prescription is an innovation in the health sector that enables patients to read the types of medication they will receive along with its description and rational use. E-prescription shortens the waiting time to get a prescription, which is different from a manual prescription system. In conventional systems, patients must undergo several steps to get served. They have to give the prescriptions to the cashier and wait for the cashier to calculate the bill. They later submit the proof of payment to the pharmacists and wait for the pharmacist to produce the medicine. Using e-prescription, the patients only have to pay for prescription and wait for the pharmacists to bring the medicine. The waiting time may decrease from 4 complicated steps into 2 simple ones. The website-based e-prescription application enables physicians to electronically send prescriptions to pharmacy computers and send its bill to the cashier. The system allows patients to directly move to the pharmacy once they have paid the bill. The research adopts a quantitative method with a prototype research model and UAT (User Acceptance Test) model for testing.

Keyword: e-prescription, prototype, pharmacy, user acceptance test

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1. Introduction

Electronic prescription is a type of health information technology that allows prescribers to send electronic prescriptions safely to the intermediary (i.e. pharmacists) by using a software [1]information technologies also may introduce different kinds of medication errors. Objective: To identify and quantify e-prescribing problems reported through an electronic prescribing incident reporting tool in the United States. Methods: Voluntary and anonymous reports to a web-based, e-prescribing incident reporting tool were collected during 18 months using convenience sampling. Questions in the reporting tool were designed to elicit information on pharmacists' experiences with e-prescribing. Data were analyzed to characterize the different types of e-prescribing concerns. Results: A total of 484 reports were collected through the incident reporting tool. Out of 484 reports, 75% corresponded to electronic prescriptions received directly into pharmacies' computers and 23% were computer-generated prescriptions faxed to pharmacies. Most of reports corresponded to comments, complaints or identified unsafe conditions regarding electronic prescriptions (49%. The electronic prescribing system is a series of prescribing processes that use software in order to simplify drug prescribing services [2]. According to the Regulation of the Minister of Health of the Republic of Indonesia, this electronic prescription system does not go against any existing laws in Indonesia [3]Emerald Publishing Limited. Purpose: This paper examines the influence of three dimensions of customer knowledge management – knowledge from customer, knowledge for customer and knowledge about customer – on innovation capabilities (speed and quality. The purpose of developing e-prescription is to reduce errors in the drug administration process and also to simplify the pharmacists's services. E-prescription can provide many benefits including time and cost savings for all parties involved[4]. It is evident in the fact that of the 25 studies conducted, 23 studies indicated the effectiveness of e-prescription in reducing the errors in drug treatment

from 13% to almost 99% [5]. E-prescription which is a web-based application has a very important role because it displays an element of the intangibility of the service itself [6]. According to a research in [7], hospital websites, despite some differences in some countries, usually function more as a place to store information and display traditional contact details. However, e-prescription can join the existing hospital website which enables the hospitals or health centers having a new unit in one application. This study aims connects the patients' prescription which is prescribed by doctors with the cashiers and pharmacists.

In some countries, research on e-prescription has been conducted extensively. However, those research emphasizes on the effectiveness of e-prescription rather than the development of the system. Meanwhile, in Indonesia, research on e-prescription is still focusing on developing an information system i.e., e-prescription to support administrative works. One of the studies that investigated the use of e-prescription and the factors influencing it have been conducted in Dr. Wahidin Sudirohusodo's clinic in Makassar. In that study, the e-prescription was partially applied in the hospital and the parts of the e-prescription were also fragmented [8]. In our study, we aim to build a web-based application system that may help the development of the e-prescription system which starts to develop.

2. Method

a. Related Works

Research that evaluate the effetiveness of e-prescription have been widely carried out in other countries. For instance, a study conducted by Amber Porterfield et al. found that e-prescription can improve the efficiency and accuracy of prescribing for patients. The results of the study suggest that electronic prescribing has the potential to improve adherence, save costs for medication, hospitals and patients, as well as increase the service efficiency for the patients [9]. Another study conducted by Yogini Hariprasad Jan et al, showed that manual prescription system had an average error of 77.4%, while e-presription only resulted in 4.8% average errors. Before the existence of e-prescription, there were 1153 items losing important information, whereas after using the e-prescription, there were only 9 items missing important information [10].

In Indonesia, most stakeholders (prescribers or physicians) use manual systems in which patients will be manually given hand-written prescriptions by the prescribers and asked to send them to the cashiers and pharmacies. Then, after giving the prescriptions to the cashiers, the patients will be asked to wait for the cashiers to calculate the amount of money that the patients need to pay for the medicine and they can make some payment. After paying the cost, the patients are requested to wait for the prescription and wait for the pharmacists to prepare the medicine. Therefore, we argue that if the stakeholders use electronic prescription, the process will be much simpler where the physicians can directly connect to the cashiers and pharmacists, while the patients just need to wait for the patient's queue number to be called and then immediately pay for the medicine. Then, the pharmacy will be immediately handling the medicine that has been previously paid. One of the studies related to e-prescription has been conducted by Puspa Setia Pratiwi and Andri Lestari. The study investigated the implementation of a clinical pharmacy prescription system. The results showed that the the clinic has developed an e-prescribing system [11]. The difference between the existing research and our study is that in our study we develop an information system with an additional feature that not only connect patients' prescriptions with the pharmacists but also with the cashiers.

Another research on the e-prescription was the one conducted by Juwita et al. The study which was conducted at Dr. Wahidin Sudirohusodo's clinical center in Makassar analyzed the implementation of the e-prescription and the factors influencing it. The results indicated that the human resources as the executors were sufficient. However, computer facilities to apply the electronic prescription and other supporting applications were insufficient causing the need for further improvement. Moreover, there were also other important works to be done such as developing the application of Electronic Drug Control (E-KPO), Electronic Medical Record (E-KPO) and Clinical Decision Support System, making connection to the clinical support results, giving education on how to run the application in the cell phones instead of computers, conducting direct monitoring throughout the room, and eliminating manual prescription sheets.

The results of the study imply that currently the electronic prescription has started to be applied. However, it is only used partially since there were still manual prescription sheets being used and the electronic prescription was still separated in from one unit to another[8]. The present study intends to fill the gaps by investigating the connections of the patients' prescriptions with not only the the pharmacy but also the cashiers so that the relationship between different units can be determined.

b. Method

To achieve the objective, the study utilized a quantitative method with a prototype research model and UAT (User Acceptance Test) as the testing system. The prototype method is a method in which a model of the software can be released first by involving several users who will generate feedback for further improvements [12]. According to Roger S Pressman, designing a system to be developed can use the prototype method. The prototype method is suitable for developing a system that will be reestablished. The

prototype is not a final product, but it is something that must be re-evaluated and modified. Any changes can occur when the prototype is made to meet the needs of the users which at the same time may help the developers understand the users' needs better [13].

The user acceptance test is usually used by clients and/or end users to identify what system can do [14]. The aim of the user acceptance test is to figure out whether or not the customers' needs have been fulfilled by the system [15]. User acceptance test is performed by the clients to find out the limitation of the software system [16]. It is also used by the users to produce documents to be used as evidence that the developed application can be accepted by the user [17]. From those claims, it can be concluded that the user acceptance test is a test used by the clients to determine the respondent's satisfaction towards the software being made.

3. Results

a. Electronic Prescription Flow

Figure 1. Electronic Prescription Flow

Figure 1 shows the flow of electronic prescribing. In the first stage, the doctor writes a prescription for the patient, and the written prescription recorded on the website will then be electronically sent to the cashier. Meanwhile, the printout of the prescription will be given to the patient as he/she has the rights to know what drug prescription he receives. After receiving the printout, the patient will have to go to the cashiers to pay for the medicine. The patient will be given a queue number and the pharmacy will give the medicine after the patient's queue number is called. When the patient takes the medicine, the printed out prescription that has been given by the doctor is submitted to the pharmacist in order to prevent a misuse of prescriptions by patients.

b. Result

To obtain a valid data, the researchers conducted the interviews with doctors, cashiers, and pharmacists at a health center / clinic. Based on the data, an electronic prescription has been established in accordance with the prescription standards that should be given by the doctor. The prescribing process encloses the information about the name of the patient, the patient's address, the name of the doctor, the date of the examination and the administration of the drug. Moreover, it also covers the information on the type of drug, the form of the drug, the dosage of the drug, and the procedure for taking the drug.

The following is a database design for the application.

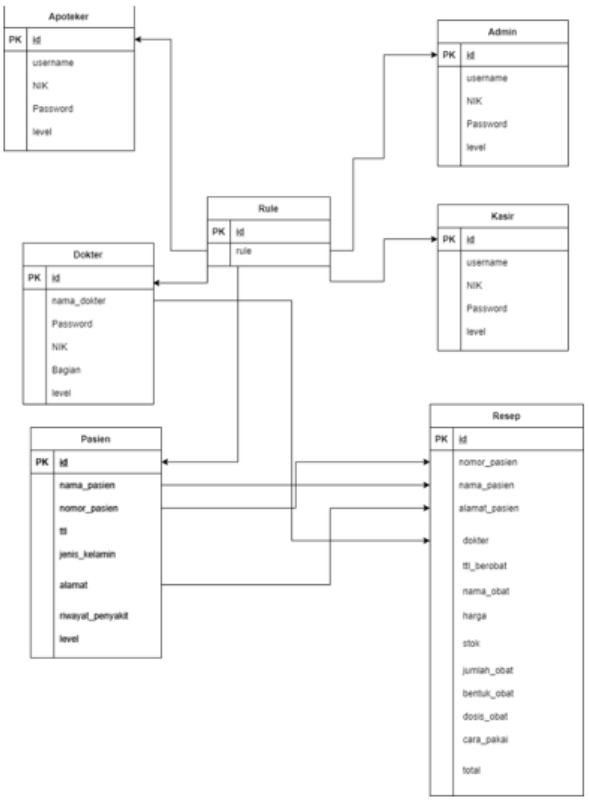

Figure 2. Database

Figure 2 shows database design from the application. The following is an overview of the created application.

Figure 3. Doctor Page

Figure 3 indicates the doctor page. On this page, the doctor can see the patient's personal information such as the patient's number, name, address, date of birth and medical record. This is provided to enable the doctor to check if there are errors in the patient's personal information, and to find out the patient's drug history to avoid any errors in prescribing the drugs.

Figure 4 shows the prescription page. In this page, the doctor needs to enter the patient's number or name, so that the patient's data will be automatically filled in. The doctor then types his/her name, the date of the examination and the drugs given. When it comes to the drug, the doctor should provide information about the number of drugs in each item, the form of the drug, the dosage of the drug and the number of times it should be taken. In this page, as the doctor selects or searches for a drug, the doctor will know the availability of the drug and its price since such information is filled in automatically

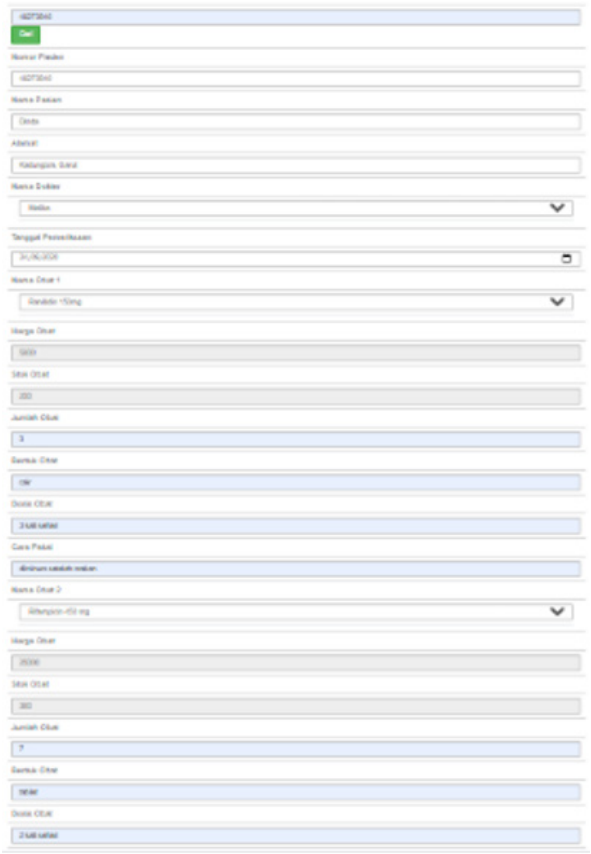

Figure 4. Prescription Page

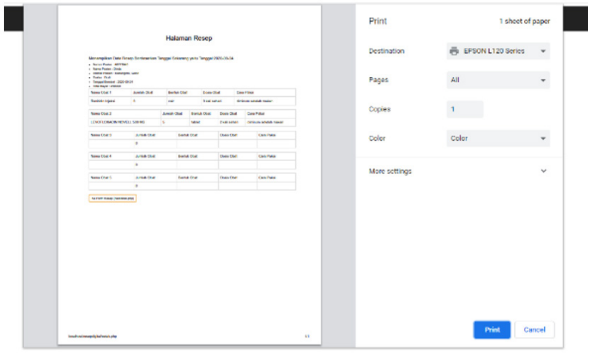

Figure 5. Prescription Print Page

Figure 5 shows a print page of the prescription. In this page, the doctor can print out the the prescription that will be given to the patient. It is important to note that when entering this page, the prescription made by the doctor will directly go to the cashier's page..

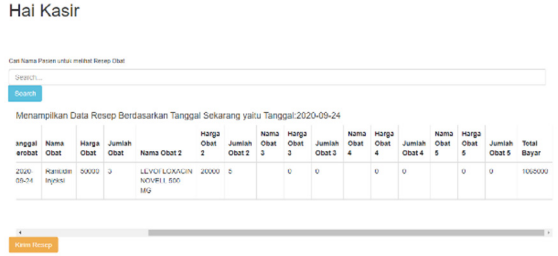

Figure 6. Cashier Page

Figure 6 displays the cashier page. In this page, the information about the patient's name, number and address, the doctor, the date of the treatment, the name, the price and the amount of the medicine, and the total that must be paid by the patient is show. This is done so that the cashier can make confirmation on the patient's information and calculate the amount of money that the patient has to pay.

Figure 7. Pharmacist Page

Figure 7 is the example of the pharmacist page. The pharmacist page shows a list of prescription made that day only. In other words, the previous data will not be displayed. On the action tab, the pharmacist can see the detail description of the drug that the patient needs.

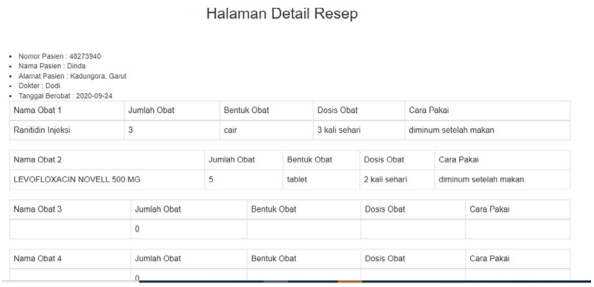

Figure 8. Detail Prescription Page

Figure 8 displays the details of the patient's prescription. This page shows the detail information about the prescription given by the doctor. The only thing that does not appear on this page is the price and total payment that the patients should make because such things will be handled by the cashier.

To protect the website from the external attacks, a security was installed on the website. The security applications installed are SSL (Secure Socket Layer) and Cloudflare. SSL serves to protect the website by encrypting the data so that the outsiders will gain no access. Meanwhile, Cloudflare serves to monitor malicious actions on the website. It helps filter and block the actions that are perceived to be dangerous

To test the functionalaity of the application, the Black Box Testing method was used. This black box testing was given to 30 respondents.

Table 1 indicates the results of the Black Box Testing. Based on the results, it can be concluded that all features are running well.

The instrument used for UAT testing was a questionnaire. The questionnaire given was in the form of 1 to 5 Likert scales with 1 as strongly disagree and 5 as strongly agree. The Likert scale was used because it is intended to measure the respondents' attitudes, opinions,

and perceptions. In this scale, the measured variable is first translated into some indicators which then serve as a starting point for arranging the instrument items which are in form of statements or questions [18].

Table 1. Black Box Testing

No	Case	Test Scenarios	Expected results	Test result
1	Login Page	Users with various roles, for example, doctor or cashier log in and are directed to their respective pages.	When the doctor enters the doctor user and clicks the login button, the doctor will be directed to the doctor page. When the cashier logs in, the cashier is directed to the cashier page.	☑ **Good**
2	Drug History	On the doctor's page, there is a button to search for the patient's name and to view patients' drug history.	When the doctor types the patient's name or patient's number in the search button, the page will immediately display detailed data about the patient including the patient's drug history.	☑ **Good**
3	Creating a new prescription	On this page, the doctor can create new prescriptions for the patients.	The prescription form functions well in which the doctor can fill in the necessary data regarding the drug description. Meanwhile, regarding the name of the drug, the doctor can immediately search for it with the dropdown features.	☑ **Good**
4	Prescription can be printed	The prescription given by the doctor can be printed and given to the patients	Patients can receive a printout of the prescription given by the doctor	☑ **Good**
5	Data can be seen on the cashier page	After the doctor fills in the drug prescription form for the patient, the data can be seen on the cashier page.	On the cashier page, the doctor's prescription can be seen along with the total payment that has been calculated on the cashier page.	☑ **Good**
6	Drug data can be seen on the pharmacist page	Pharmacists see drug data required by the patient	The detail information about the prescription from the doctor can be seen by the pharmacists .	☑ **Good**

Table 2. Likert Scale

Statement	Answer (Score)	
	Positive (+)	Negative (-)
Strongly Agree / Always / Very Appropriate	5	1
Agree / Often / Appropriate	4	2
Uncertain / Occasionally / Neutral	3	3
Disagree / Almost never / No corresponding	2	4
Strongly disagree / Never / Strongly it is not in accordance	1	5

The performance of the developed web-based application was tested by using gtmetrix.

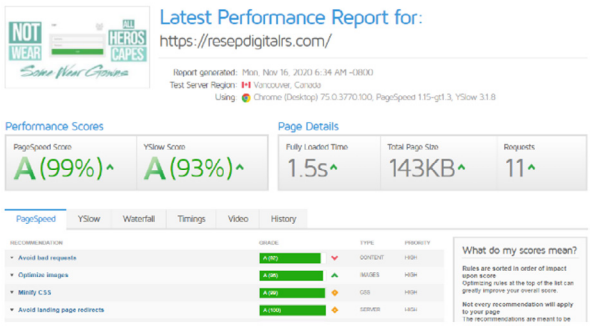

Figure 9. Result of the website performance

Figure 9 shows the result of the website performance. Website has 99% to page speed score, 93% for Ylow score, and fully loaded time 1,5 second.

4. Discussion

To obtain the data regarding the use of the system, several questions were formulated.

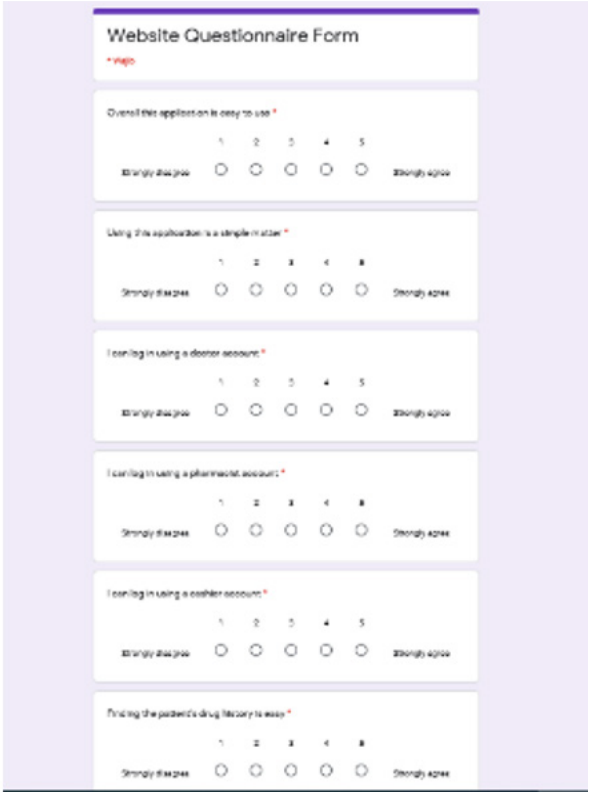

Figure 10. Questionnaire Form

Figure 10 shows the questionnaire administred to the respondents to get the desired data. The questionnaire consists of 12 questions or statements which can be seen in Table 3.

Table 3. Questions or Statements in the questionnaire

Number	Question or Statement
Q1	Overall this application is easy to use
Q2	Using this application is very simple
Q3	I can log in using a doctor account
Q4	I can log in using a pharmacist account
Q5	I can log in using a cashier account
Q6	Finding the patients' drug histories is easy
Q7	Creating new prescriptions for the patients is easy
Q8	Printing a doctor's prescription is easy
Q9	Viewing the list of patients who have to pay is easy
Q10	It is easy to see how much a patient has to pay
Q11	Viewing the list of patients who need to prepare the drugs is easy
Q12	Viewing the prescription along with its detail descriptions is easy

Table 3 outlines the questions or statements given to the respondents. The number of statements or questions given is 12. The results of the questionnaire given to 30 respondents can be seen in Table 4.

Table 4. Respondent's Responses

Respondent's Responses					
Question	Strongly Agree (5)	Agree (4)	Uncertain (3)	Disagree (2)	Strongly disagree (1)
Q1	15	6	9	1	0
Q2	15	10	4	1	0
Q3	15	3	10	1	2
Q4	15	5	8	1	2
Q5	11	6	10	1	3
Q6	13	6	10	1	1
Q7	10	9	8	3	1
Q8	12	8	9	1	1
Q9	12	6	11	0	2
Q10	13	8	8	0	2
Q11	9	13	8	0	1
Q12	15	6	7	2	1
Sum	155	86	102	12	16

Table 4 covers the results of the questionnaire. The number of respondents who chose to give score 5 was 775, the number of respondents who chose to give score 4 was 344, the number of respondents who chose to give score 3 was 306 the number of respondents who chose to give score 2 was 24 and the number of respondents who chose to give score 1 was 16. The total score was 1465.

The highest score was 30*12*5 = 1800, and the lowest score was 30*12*1 = 360. The percentage of the results was 1465/1800*100% = 81,39%. Classifications for usability have 5 classification. First, 0%-20% is very weak, 21%-40% is weak, 41%-60% is enough, 61%-80% is strong, 81%-100% is very strong. Based on the results, it can be inferred that the level of the website application system usability is very strong.

Although there were positive results, some improvement on some parts still need to be made. There is a limitation on the part of the cashier payment system which is yet connected to the bank. Therefore, it will be beneficial to collaborate with the bank which may enable the prescription payment to be done online through mobile or internet banking. In addition to the payment system, the security of the website also needs to be improved so that it will not be depended on the third parties for its security.

5. Conclusion

Based on the result, it can be said that the applications that have been built runs quite well. It is evident in the fact that the prescription given by the doctor can be electronically sent to the cashier and pharmacist and be printed out for the patients. This causes the patient's waiting time to be shorter. For further development,

the pharmacy can collaborate with the bank to make the payment process easier. By this way, the patients can pay for the prescribed drugs through mobile or internet banking which may help shorten the waiting time of the patients to get the medicine.

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khazanah informatika

Jurnal Ilmu Komputer dan Informatika

Measurement Motoric System of Cerebral Palsy Disability using Gross Motor Function Measure (GMFM)

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Abstract-Cerebral palsy (CP) is a mobility disorder, muscle tone or posture disruption caused by brain damage that appears during brain growth, and often occurs before birth. CP has an impact on the daily activities of the suffered patient. Gross Motor Function Measure (GMFM) is a type of clinical measurement to evaluate development progress in the motoric function of CP patients. The purpose of this research is to design software to monitor and evaluate motoric parameters of CP patients. The software implements the GMFM method. The development mechanism went through the process of Software Requirements Specification (SRS). The result shows that the software helps monitor and evaluate CP patients. Software application in the field assists in evaluating the initial examination of T-1 until the final examination of T-6. Records show the enhancement dimensions of lying and rolling by 13.3%, sitting 14.8%, crawling and kneeling by 15.7%, standing by 16.5%, and walking-running-jumping 17.4%. We conclude that the application supports recording and analyzing motoric cerebral palsy data.

Keywords: Cerebral palsy, child, Gross Motor Function Measure (GMFM), Unified Software Development Process

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1. Introduction

World Health Organization (WHO) in 2003 estimated that the number of disabilities in Indonesia around 7-10% of the total population of Indonesia. Most of the children with disabilities or around 292,250 children are in the community under the guidance and supervision of parents and families. In general, they have not received proper health services[1]. This disability arises because of congenital birth or acquired after birth. The factors that influence are natal, prenatal, postnatal, and socioeconomic[2].

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation [3]. Cerebral palsy (CP) is a disorder of movement, muscle tone, or posture caused by brain damage that occurs during the period of brain development, and most often occurs before birth. CP is a form of the physical disability that is most often found in childhood. Although CP is non-progressive, it has an impact on the daily life activities of people with CP for their whole life. The most obvious characteristic of CP is motoric disorders including spasticity, motoric control disorders, and muscle weakness. This motoric disturbance can cause limitations in mobility activities related to walking or climbing stairs. In recent decades, the prevalence of CP throughout the world continues to increase, including the prevalence in Indonesia[4].

Most of the relatives around the CP patient do not have latrines and still keep pets around the backyard, therefore the surroundings become increasingly slum-like. In the Puskesmas, during Posyandu services, programs are made to assists counseling to the community of pregnant women to check their pregnancies, therefore that initial abnormalities in pregnancy can be identified and they can be treated promptly and adequately. Furthermore, mothers of under-five children are also given counseling on how to identify signs of child malnutrition and how to provide correct food for toddlers, as a result, the problem of malnutrition and malnutrition can be decreased in the area of the Puskesmas[5].

Research [6] stated that although discussion about the characterization of CP has tracked a trajectory, the discussion about the initial age at which CP can be precisely diagnosed is a recurrent theme. The idea that premature diagnosis is vital to guarantee early access to illness-specific intervention to reduce the influence of CP has been elevated in the literature for centuries. As far back as the

first explanation of cases of CP in the 1800s, William Little made the argument for earliest potential identification with the purpose of "stimulate favorable treatment of the disorders when identified in the early phases". This started the generally recurring argument that earlier diagnosis can lead to the earliest potential intervention.

Kids with CP usually present with growing delay and motor deficits. The variance between a static (non-progressive) and progressive medical course is very significant. Naturally, loss of previously acquired milestones (regression) marks the onset of most metabolic and neurodegenerative disorders (NDD). However, some NDD or metabolic disorders take a slow rate of advancement and can be misdiagnosed as CP. Consequently, perfect developmental regression may not be evident, particularly in the early phases of the illness or at a younger age of onset. Furthermore, the neurological consequences of CP may be postponed for several months because of the immaturity of the nervous system[7].

Research [8] provides a checklist approach that defines the roles of various healthcare providers. The checklist is an instrument that respects the time-based priority of data collection using different numbers: 1, 2, and 3. It contains five vertical pillars in which the third and the fourth are the most significant ones for the checklist: a notice to accumulate all the important data that can be valuable in the upcoming assessment of the case.

Various treatment interventions have been used to give spasticity in children with CP. The choice to use any specific treatment intervention is conducted by the aim of the treatment. In some cases, the aim may be to decrease focal spasticity, while in others it may be to decrease generalized spasticity. Similarly, the risks and benefits of any particular intervention should be wisely considered. Physiotherapy and job-related therapy by age 4–5 years of age have been shown to be relatively more effective than if started at a future age. Botulinum toxin injection is used to treat focal spasticity with the best usefulness between 1 and 6 years of age for the treatment of lower extremity spasticity and between 5 and 15 years of age for spastic hemiplegia. Spasticity supervision is best conducted by a physician with expertise and experience with the use of various treatment interventions [9].

The GMFM has been applied widely. It has been adopted globally and has been used as a descriptive stratification system to discover a wide range of issues, such as the risk of hip migration in children with CP and the distribution of function in a population-based list of children and youths with CP [10]. These uses demonstrate how a consistent and valid functional classification system can be used to stratify children along with a specific attribute of the function. It can assist to classify the extent to which variations in that attribute contribute to variation in any of some other attributes.

Gross Motor Function Measure (GMFM) is a type of clinical measurement to evaluate changes in gross motor function of patients with CP. The measurement consists of 88 examination items; such as activities in the lying and rolling position (17 items), sitting (20 items), running, and jumping (12 items). The assessment of GMFM consists of 4 scores, each of which has the same meaning even though the description is different depending on the item's ability being assessed. The value of GMFM describes that 0 = no initiative; 1 = there is an initiative; 2 = partially equipped; 3 = equipped; NT = Not Tested (not tested).

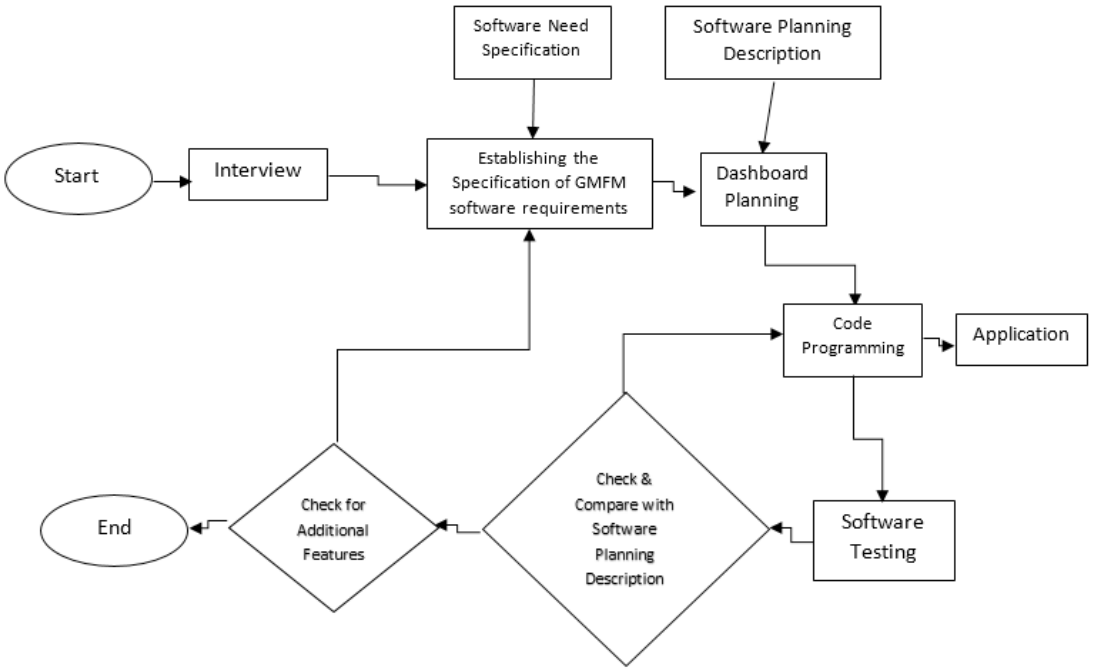
2. Method

The application design in this study was developed using the Unified Software Development Process method and Unified Modeling Language (UML). UML was meant to be a unifying language enabling IT professionals to model computer applications. The Unified Software Development Process (USDP) or Unified Process (UP) is a methodology software development, especially oriented software object which consists of 4 phases; Inception, Elaboration, Construction, and Transition. The USDP method is more often used for a build framework (framework) that can be customized for the benefit of the organization and more specific projects [11].

The phases in the Unified Software Development Process or Unified Process based on Pressman [12]) consists of preliminary, expansion, design, and transition. This research includes the process of making a Software Requirements Specification and Software Design, then followed by making an application and closing with testing. This process is carried out continuously according to the planning period.

This research method includes interviews with physiotherapists at YPAC (Yayasan Pembinaan Anak Cacat – Disabled Children Development Foundation) in Surakarta which is a case study conducted for GMFM (Gross Motor Function Measure) with Cerebral Palsy cases. This method discusses the quality of the coordination patterns of motoric sensor problems and functionalities of daily life. The output of this phase is the specification of software requirements and interfaces. The output includes the initial interface design on the GMFM menu and the calculation of the GMFM dimension. The initial interface is then being analyzed to be a reference in developing a software requirements specification document.

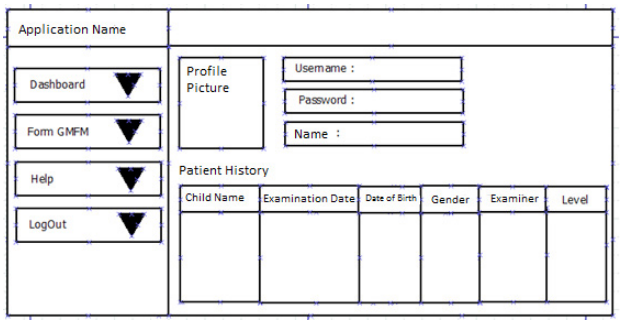
Research [13] stated that the supervision contains neurological rehabilitation (addressing muscle tonal abnormalities, and devising bodily and work-related therapies) and identification and management of co-morbidities (including epilepsy, impairment of cognition, visualization, hearing, and instabilities of growth and gastrointestinal utility). The supervision, consequently, is multidisciplinary including the treating physician working with a team of rehabilitation-, orthopedic, psychological-, and social care- providers. Moreover, research [14] specified that the effectiveness of rehabilitation interventions for children with CP is still questionable. Functional ability and social contribution should be the leading outcome measures in evaluating rehabilitation effectiveness.



Research Flowchart

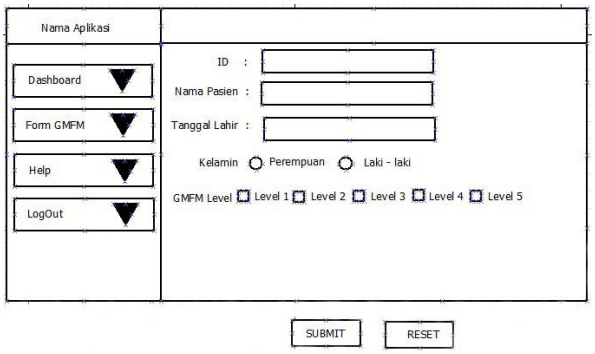
The diagnosis of spasticity in children with CP involves a comprehensive physical inspection, with additional testing as required [15]. The purpose of treatment is to encourage the child to acquire to be as independent as possible. Some children who have slight cerebral palsy will not take any difficulties in accomplishing independence. For others, it will be a slow process. In some with severe difficulties, considerable support from others will always be required. Specific treatment differs by individual and changes as needed if new issues develop. In general, treatment focuses on ways to maintain or improve a person's excellence of life and overall health.

The main interface displays the identity of the user, the identity of the CP patient, and the result of the measurement calculation of GMFM.



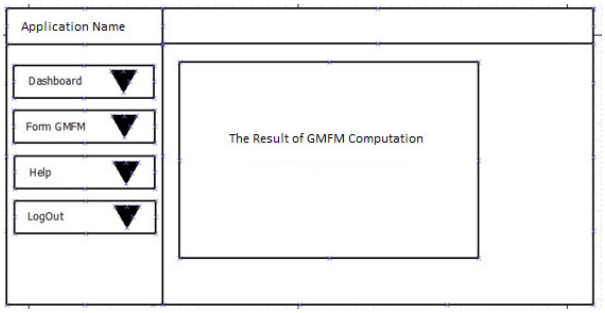
Main Interface Display Design

The design of the interface allows users to input some variable inputs; the name of the patient, birth date, gender, and *GMFM level*. There are two action buttons on the page, submit and reset. The submit button performs the input action that has been recorded while the reset button will cancel all entries. The interface is shown in figure 3.



Entry data of the patient

The result of measurement is displayed in the other interface. The output will be recorded in percentage and graph. The application allows users to save the document in PDF format. The design of the output interface is shown in figure 4.

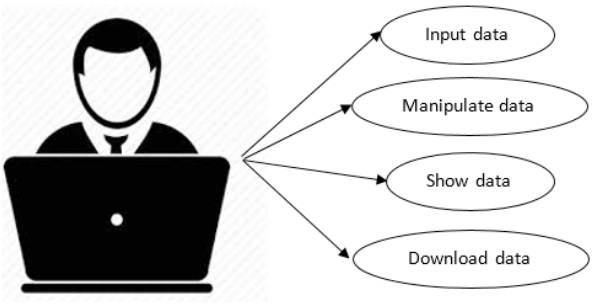


The Design interface of GMFM Measurement

The result of this stage is the specification of the software requirements document and the initial interface of the planning stage and then it is analyzed as a reference

for making UML; such as use case, interface, database design, and system design. This application is developed by translating UML at the design stage into programming code.

Use case diagrams consist of actors as users that can be used in general. Actions that users allowed to take include inputting data, processing data, viewing data, and downloading data as shown in figure 5.



***Use case* diagram**

Data taken include changes in functional capacity and GMFM (Gross Motor Function Measure). Functional capacity is measured from 0 (cannot be moved at all) to 1 (can do independently). GMFM (Gross Motor Function Measure) is a type of clinical measurement to evaluate changes in gross motor function of patients with CP. There are 88 examinations in GMFM.

a) GMFM dimension A (lying down): 17 examinations
b) GMFM dimension B (sitting): 20 examinations
c) GMFM dimension C (crawling): 14 examinations
d) GMFM dimension D (standing): 13 examinations
e) GMFM dimension E (running): 24 examinations

GMFM assessment consists of 4 scores; 0 = no initiative, 1= there is an initiative, 2 = partially complete; 3 = complete; and NT= Not Tested. Therefore the maximum score are:

a) GMFM dimension A (lying down): 51
b) GMFM dimension B (sitting): 60
c) GMFM dimension C (crawling): 42
d) GMFM dimension D (standing): 39
e) GMFM dimension E (running): 72

The score of each dimension is converted into a percentage to calculate the GMFM score. The way to measure GMFM is if the dimension item is executed then NT = 1, and if the dimension item is not executed then NT = 0.

3. Result and Discussion

The application of motoric measurement of cerebral palsy children with GMFM consists of the initial appearance, dashboard, GMFM form, and also help menu that contains the terms and conditions. The initial page can be seen in Figure 6. The initial page consists of a username, password, and name. There is a patient history table that shows a patient history that includes the child's name, date of examination, date of birth, sex, examiner, level, and the number of patients.

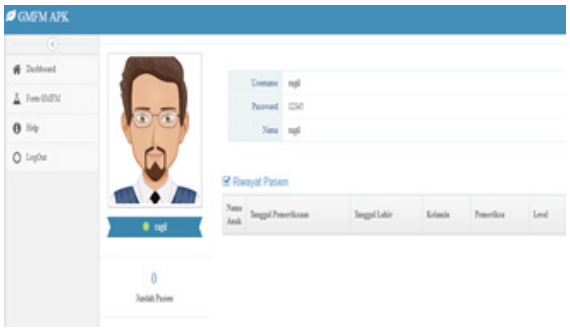


Figure 1. The initial page consists of the identity of the CP patient

The patient form page must be filled by the patient's identity then recorded to the system by the user which includes the id, the patient's name, date of birth, gender, and GMFM level. After the patient form is filled in, there are two button options; to record with submit button and to erase entry data or to repeat if there is an error in filling out the patient form with a reset button, as can be shown in Figure 7.

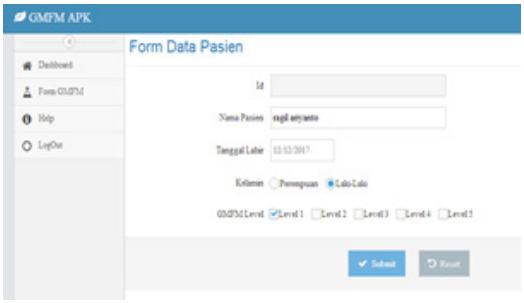


Figure 2. Patient Data Form

Figure 8 shows the content of a form that will be filled by the user and there are five dimensions of GMFM consisting of lying and rolling dimensions (17 items), sitting dimensions (20 items), crawling and kneeling dimensions (14 items), standing dimensions (13 items) and dimensions of walking, running, jumping. The way to assess there is no initiative (value 0) not test, there is an initiative (value 1), partially completed (value 2), completed (value 3) to choose according to the condition of patients to be tested. The results of selecting the GMFM dimension can be seen in Figure 8.

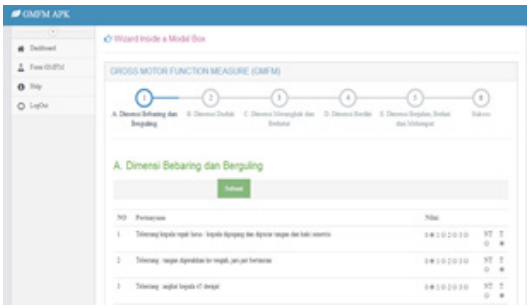


Figure 3. GMFM Item Measurement

Figure 9 is the result of data entered by the user in the selection of dimension items. The user allows printing the result in PDF format. Data that has been recorded is then processed into information needed by the patient to perform motoric development.

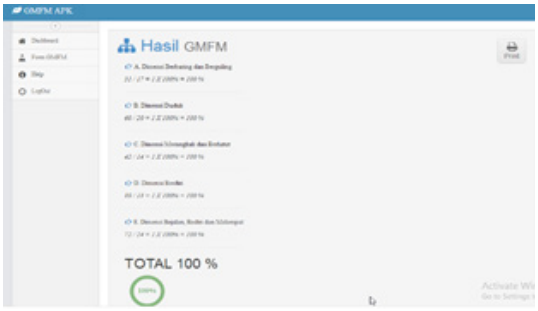


Figure 4. GMFM Measurement Result

The research conducts a black box testing method to evaluate the system. Software testing is necessary to ensure the applications that have been developed can run by the expected functionality[16]. Application testing is focused on the function of the motoric measurements, therefore the results show the accuracy of motoric measurements of the patient. Testing the motoric measurement application with the black box method can improve the quality of the system.

The formula used to calculate the measurement of a motoric parameter of the cerebral palsy patient.

$$X_1 = \sum_{i=1}^{17} \frac{A_i}{51};\ X_2 = \sum_{i=1}^{20} \frac{B_i}{60};\ X_3 = \sum_{i=1}^{14} \frac{C_i}{42};\ X_4 = \sum_{i=1}^{13} \frac{D_i}{39};\ X_5 = \sum_{i=1}^{24} \frac{E_i}{72}$$

where X_1 is the variable of the average score of dimension A (17 measurements of lie down and roll), X_2 is the variable of the average score of dimension B (20 measurements of sitting), X_3 is the variable of the average score of dimension C (14 measurements of crawling and kneeling), X_4 is the variable of the average score of dimension D (13 measurements of standing up) and X_5 is the variable of the average score of dimension E (24 measurements of wall-run-jump). The total GMFM score is determined by the sum of all averages of the GMFM dimensional score.

$$Total\ Score\ of\ GMFM = \sum_{i=1}^{5} X_i$$

The main definition of muscle strength is the value of the maximum ability of muscles or muscle groups to perform or maintain a certain pattern of movement[17]. The application of cerebral palsy motoric measurement provides significant improvements in gross motor function including a decrease in spasticity after the intervention within 6 weeks of treatment.

Measurement of functional ability with GMFM includes 88 items. This functional ability measurement is completed on lying and rolling, sitting, crawling and kneeling, standing items, and walking-running-jumping items. From the initial examination of T-1 until the final examination of T-6, the result shows the enhancement dimensions of lying and rolling by 13.3%, sitting 14.8%, crawling and kneeling by 15.7%, standing by 16.5%, and walking-running-jumping 17.4%. Therefore, it can be concluded that the examination of functional abilities increased in every dimension of GMFM.

Table 1. The result of examination cerebral palsy patient

No	Dimension	T1	T2	T3	T4	T5	T6
1	Lie down and roll	10,48%	10,83%	12,44%	10,98%	12,55%	12,44%
2	Sitting	13,25%	13,44%	14,48	16,55%	17,83%	17,83%
3	Crawling and kneeling	14,44%	15,83%	16,55%	17,55%	17,25%	17,83%
4	Standing up	12,55%	17,83%	18,48%	18,83%	19,48%	19,98%
5	Walk, run and jump	15,44%	16,48%	16,98%	18,83%	17,48%	18,98%
	Score	13,3%	14,8%	15,7%	16,5%	16,9%	17,4%

4. Conclusion

The application of a motoric cerebral palsy measurement is accomplished and meets with both the initial goal of application development and calculation analysis of motoric cerebral palsy. The data was recorded and being medical physiotherapy records. Data entry from the user processed and becomes historical medical record information for the cerebral palsy patient.

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